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UTILIZATION OF NEWFOUNDLAND AGGREGATES TO PRODUCE CONCRETE FOR OFFSHORE STRUCTURES

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UTILIZATION OF NEWFOUNDLAND AGGREGATES TO PRODUCE CONCRETE FOR OFFSHORE STRUCTURES

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1.0 INTRODUCTION

The anticipated construction of offshore oil drilling platforms in the Hibernia Field has led to interest in the potential for producing high strength concrete from materials available in Newfoundland. A review of present technology shows that there has been little related research and some offshore developers have raised questions with regard to these potentials. This question was specifically raised at the Gaithesburg Maryland Conference "International Workshop on the Performance of Offshore Concrete Structures in the Arctic Environment" sponsored by NBS and CANMET, March, 1983.

The test program was designed to provide basic trial mix data using materials available in Newfoundland. Although aimed at the offshore questions, it provides data also for other high strength concrete considerations.

The program consisted of initially identifying three aggregate sources with good potential for the production of high strength concrete, developing a specification for the aggregate and procuring and processing chosen aggregates to the specification.

The processed aggregates were then used in the preparation of a series of 9 trial mixes which included cementitious materials and admixtures readily available in Newfoundland. The trial mixes were tested for durability, strength and other properties.

It was intended that the results of this program would provide information on the properties of concrete made with Newfoundland materials for use by designers of offshore and other structures for preliminary calculations for high strength concrete elements.

2.0 SCOPE OF INVESTIGATION

The Contract's Statement of Work is presented in Appendix A. Nolan Davis interpreted this to have the objectives of:

Primary:

1) to determine whether high strength concrete can be produced using Newfoundland aggregates and cement

2) to obtain an indication of the freeze-thaw durability of concrete made with three different Newfoundland coarse aggregates, a Newfoundland natural fine aggregate and a Newfoundland cement, all representing potential sources for high strength concrete.

Secondary:

3) to obtain further data on the ratios of compressive to flexural and splitting tensile strength

4) to obtain further data on typical laboratory batch uniformity

5) to obtain further data on the ratio of large to small size cylinder compressive strength

6) Provide designers with data on properties such as shrinkage and modulus of elasticity of concretes made with Newfoundland materials.

3.0 AGGREGATES

3.1 Sourcing of Materials

Consultation was held with the Scientific Authority with regard to sourcing of cement, silica-fume and admixtures. Canadian manufacture was emphasized, Newfoundland manufacture in the case of the Portland cement.

The Newfoundland Department of Mines and local contractors has identified three sources of coarse aggregate, two quarry sources and one gravel, and one of natural sand that had potential for the production of high strength concrete. The Department had done some preliminary investigation of the soundness and probable quantities at these sources.

A description of the aggregates and their locations is presented in Appendix B. They may be generally described as:

Granite from Toby Lookout

A medium grained massive granite, pink to black in color, located in a raised plateau outcrop.

Sandstone from Placentia Bay

A fine-grained, well cemented brown sandstone of predominate quartz.

Gravel, Stone and Sand, from Swift Current

An alluvial deposit of highly variable mineralogy but predominantly volcanics. Deposit stratified with variable coarse: fine ratios. Sand is sub-round quartz particles.

3.2 Aggregate Processing

It was originally intended that aggregates be mined and subsequently processed by crushing, screening and washing. This work was to be done under separate DSS Contract to a local Contractor and administered by Nolan Davis. An appropriate specification was prepared - Appendix "B". Tenders for this work were far in excess of available funds and it was necessary to reorganize the program by reducing the coarse aggregate sources to two, reducing quantities and having more of the work done by Nolan Davis. No small-scale aggregate processing equipment was available.

By a subsequent Contract, the third aggregate source was reintroduced to the program.

Mining was done by a local blasting Contractor. Rock was transported to the Toronto laboratory of Trow Inc. for crushing, screening and washing. For the gravel source, material was selectively excavated from the bands within the deposit. It was screened through a 50 mm screen on site and then subsequently crushed and screened in Toronto.

The fine aggregate was shipped to Toronto in two separate deliveries. These two were treated differently as follows:

Shipment 1: Prior to shipment of the sand to Toronto, the sand was blended with a fine blend sand obtained from a source in close proximity to the gravel excavation area. The blend sand was added at a rate of 8% by mass of the fine aggregate with blending being performed in a revolving drum mixer. Fineness modulus was found to be at the lower end of the desirable range for high strength concrete. This sand was used in mixes 2, 4 and 5.

Shipment 2: This sand was delivered to the Trow laboratory without any prior processing in Newfoundland. After screening of the sand through a 5 mm sieve, sieve analysis was performed on the remaining fine aggregate. This sand was found to give a closer agreement with the specified grading than the shipment 1 sand and a higher fineness modulus was achieved. This sand was used in mixes 1, 3 and 6.

3.3 Aggregate Properties

Aggregate properties are presented in Appendix C.

The aggregates had exceptionally high soundness values, good shape factors and low petrographic numbers. Aggregate grading generally complied with the project requirement. However, all were slightly low for % retained on the 14 mm sieve.

4.0 CONCRETE MIXES

4.1 Materials

(i) Cement

Cement was a Newfoundland Type 10 cement supplied by North Star Cement Ltd. The physical properties and chemical analysis of the cement are given in Appendix D.

(ii) Silica Fume

This was supplied by SKW, Canada from their Becancour plant in Quebec. Chemical analysis and physical properties are given at Appendix D.

(iii) Chemical Admixtures

All chemical admixtures - superplasticizer, water reducer and air entraining agent were supplied by Conchem as follows:

Air Entraining Admixture: Proair

Superplasticizer: Conchem SPN

Water Reducing Admixture: Prolex R

Details are provided at Appendix E.

4.2 Mix Proportioning

Cementitious factors, water/cement ratio, slump and entrained air content were designated by the Scientific Authority - see Appendix A.

Initial trial mixes indicated that the specified w/c ratio would not give satisfactory plastic properties with the materials available. After discussions with CANMET, the target w/c ratio was increased to 0.29.

In proportioning, consideration was given to producing reasonable workability, as well as maximum strength. This was necessary because use of this concrete in offshore structures was expected to involve pump placement and slipform. To more properly reflect the proposed eventual use of the concrete, the slump requirement of 75 - 100 mm was revised to allow higher slumps than 100 mm.

Mixing procedure was in accordance with CSA Standard CAN3-A266-6-M85. Mix proportioning data for the concrete mixes is given at Appendix F.

4.3 Properties of Fresh Concrete

Mixes Nos. 1, 2, 4 and 5 all stiffened rapidly after mixing. This can probably be attributed to the combination of high cement content, low water/cement ratio and the high superplasticizer dosage needed to achieve workability. In Mixes 1 and 4 high temperature may also have affected the stiffening rate.

For each concrete, considerable variation in the amount of superplasticizer needed to achieve the required workability was observed between batches.

Several batches of concrete had to be mixed in order to obtain three batches with the required properties. In view of the high between-batch variability it was decided to make the superplasticizer dosage variable in order to achieve the required slump while all other constituents were kept constant.

However, the first mix, Mix No. 2, was prepared with constant superplasticizer dosage which led to a wide spread in slump measurements. This wide workability spread is reflected in the testing results. This mix was repeated and is presented as "mix 2 repeat (2R)" in the results tables. Testing of specimens from the three batches of Mix No. 2 are also reported.

The properties of the fresh concrete, i.e. temperature, slump, unit weight and air content are given at Appendix F, specified fresh concrete properties are given in Appendix A.

5.0 TESTING

5.1 Preparation of Specimens

The number, size and type of specimens fabricated for each mix are listed in the 'Testing Schedule for Hardened Concrete' in Appendix G.

Cylinder specimens were made using heavy wall plastic moulds and all other specimens were cast using steel moulds in accordance with ASTM Specification C192-81 - Standard Method of Making and Curing Concrete Test Specimens in the Laboratory.

In order to fabricate the required number of specimens , three batches of concrete were required for each mix.

For each test on the hardened concrete, specimens were prepared from different batches in order to derive a mean strength for the design mix (e.g. 3 day compressive strength for mix #1 was obtained by testing one specimen each from batches 1, 2 and 3).

Specimens were cured in moist room conditions in accordance with ASTM C192-81.

5.2 Testing of Specimens

The list of tests and the appropriate ASTM Standard to which the specimens were tested are given in the "testing schedule for hardened concrete" at Appendix A. For the strength and modulus of elasticity tests, three specimens were tested. For air void, shrinkage and freeze-thaw two specimens were tested.

For the shrinkage tests, the initial measurements were taken with equipment which was later found to be faulty thus the initial readings are inaccurate. However the measurements taken at 28 days and later are accurate. Readings taken are shown in Table XI. Change in length during the dry storage is shown graphically in Figures 12 to 17.

All nine mixes were tested for compressive strength (both 150 mm x 300 mm and 100 mm x 200 mm cylinders), flexural strength, splitting tensile strength, modulus of elasticity, shrinkage and air void content of the hardened concrete.

For the rapid freeze-thaw test, only the mixes containing silica fume were tested for freeze-thaw durability as required by the Statement of Work schedule (Appendix A).

6.0 TEST RESULTS AND THEIR ANALYSIS

6.1 Compressive Strength Development

Compressive strength test results are given in Appendix H and shown graphically in Appendix I.

All the mixes continued to gain strength up to 365 days.

a) Cementitious Content

For granite and gravel concretes, a 450 kg/m^3 cement content produced somewhat higher strength than the 500 kg/m^3 cement content in both cylinder sizes and almost all test ages.

The silica fume mixes, with the exception of the gravel mix at 365 days, consistently achieved higher strength than the cement only mixes. The addition of 32 kg/m^3 of silica fume to the 450 kg/m^3 cement content produced a strength increase averaging approximately 14% at 91 days and approximately 12% at 365 days.

At three days, strengths for granite, gravel and sandstone cement only mixes were similar (large cylinders 37.3 - 39.9 MPa, small cylinders 36.4 - 42.6 MPa). The silica fume mixes produced higher strength (large cylinders 40.2 - 43.5 MPa, small cylinders 40.0 - 44.9 MPa) than the cement only mixes.

b) Aggregate Effect

The 91 day strengths for all the silica fume concretes for all three coarse aggregates were over 70 MPa. Results from the 300 mm x 150 mm diameter cylinders are within 1.1 MPa of each other (75.8 - 74.7 MPa). The tests on the 200 mm x 100 mm diameter cylinders show a

wider strength variation between aggregates with the sandstone mix achieving the highest mean strength. Strengths at 28 days also show higher compressive strength in the sandstone specimens.

The sandstone aggregate concrete generally experienced a lower rate of strength gain between 91 days and 365 days than the gravel and granite concretes.

The granite and gravel mixes displayed similar performance at 365 days in the cement only mixes, producing somewhat higher strengths than the sandstone mixes.

For the silica fume mixes, the gravel concrete produced approximately 10% lower strength than the granite concrete. The sandstone concrete strengths were somewhat lower than those of the granite mixes but higher than the gravel.

Test results indicate that it would be possible to design 70 MPa class concrete mixes using any of the three coarse aggregates and complying with the strength requirements at 91 days.

6.2 Flexural Strength

The granite and sandstone aggregates displayed modulus of rupture of over 9 MPa in the silica fume mixes. The corresponding cement-only mixes had a lower modulus of rupture. These results therefore follow the pattern of the compressive strength tests.

The gravel aggregate concretes all had a modulus of rupture in the 7 MPa range. This probably indicates the flexural/tensile limitation of the cement-aggregate bond or of the aggregate itself.

6.3 Splitting Tensile Strength

The splitting tensile strength results did not follow the pattern of the flexural and compressive strength tests. The sandstone aggregate-silica fume mix had a comparatively low splitting tensile strength at 28 days (however, since the 14 day strength was 450 KPa higher this may be due to the individual test).

The mixes containing 450 Kg/m^3 of cement also consistently out performed the 500 kg/m^3 cement content mixes.

The three aggregates could all be expected to achieve splitting tensile strengths of 4500 KPa at 28 days in a well designed mix.

6.4 Modulus of Elasticity

The sandstone aggregate mixes all achieved a 91 day modulus of elasticity in the 39 GPa range (5.6×10^6 psi).

Gravel aggregate concretes were in a lower range from 35.4 - 37.2 GPa ($5.1 - 5.4 \times 10^6$ psi) and the granite aggregate was 33.2 - 34.0 GPa ($4.8 - 4.9 \times 10^6$ psi).

These values are comparable to the previous findings of various researchers (3) for Modulus of Elasticity of high strength concretes.

6.5 Freeze-Thaw Durability

The durability factors for concretes of the three different aggregate types are given below:

From ASTM C-666, Durability Factor (DF) = $\frac{PN}{M}$

where P = Relative dynamic modulus of elasticity at N cycles (%).

N = Number of cycles at which P reaches the specified minimum value for discontinuing the test or the specified number of cycles at which exposure is to be terminated, whichever is less, and

M = Specified number of cycles at which the exposure is to be terminated.

By interpolation, modulus of elasticity for the gravel and granite aggregates reached the ASTM suggested minimum value (60% of the initial modulus) at 248 and 215 cycles respectively.

a) Sandstone D.F. $= \frac{93.7 \times 300}{300}$

$= 93.7$

b) Gravel D.F. $= \frac{60 \times 248}{300}$

$= 49.6$

c) Granite D.F. $= \frac{60 \times 215}{300}$

$= 43.0$

Note that the Durability Factor for the granite specimens is based on one specimen only as the companion specimen failed at 125 cycles when it broke into two. The freeze-thaw durability of the granite aggregate concrete is therefore in doubt.

The sandstone aggregate specimens were considerably superior to the granite and gravel specimens and freeze-thaw damage to these specimens at over 300 cycles was relatively small. Clearly, the air void system is the key factor in freeze thaw performance and this is discussed further in section 6.7.

6.6 Shrinkage

Shrinkage at 448 days varied between 0.048% and 0.087% for the nine mixes (i.e. 480 - 1870 x 10^{-6}).

The mixes with the highest paste content experienced the highest shrinkage. For similar mixes the gravel concrete had the highest long term shrinkage. The sandstone and gravel mixes had similar shrinkage characteristics.

6.7 Air Void Analysis

The target air content was revised from the original requirement of 4 ± 0.5% to 5 ± 1% after discussions with CANMET. Generally the concrete mixes met this requirement.

Analysis of the air void system in the hardened concrete showed that air contents generally were lower than measured in the plastic concrete by up to 2.4 percentage points leading to actual air contents which were somewhat lower than specified (ranging from 2.5 - 5.1%).

The concretes which were subjected to freeze/thaw cycles had entrained air systems as follows:

	Plastic Concrete	Air Hardened Concrete Content	Specific Surface mm^{-1}	Spacing Factor mm
Sandstone (Mix 9)	4.5%	4.4% (mean)	19.1	0.256
Granite (Mix 3)	4.2%	3.8% (mean)	26.1	0.206
Gravel (Mix 6)	4.5%	4.8% (mean)	26.5	0.200

These air contents are normally considered adequate for this class of concrete and the ASTM C-666A exposure conditions. However, spacing factors were borderline.

The petrographic numbers and the losses in the magnesium sulphate tests of the granite and the gravel do not indicate that these two coarse aggregates will perform poorly in concrete in the freeze-thaw test. Although the air void system of the two concretes was somewhat better than that of the sandstone concrete, it was borderline and further freeze-thaw testing should be carried out to confirm the results of this test series.

6.8 Comparison of 300 mm x 150 mm diameter cylinders vs 200 mm x 100 mm diameter cylinders

The results produced using 100 mm diameter x 200 mm cylinders for compressive strength give a good correlation to the 150 mm diameter x 300 mm cylinders.

The summary of the regression analysis of the relationship between testing of the different size specimens is as follows:

Regression Equation: $Y = 5.9735 + 0.88058X$ MPa
(Y ordinate being 100 mm diameter x 200 mm cylinders)

Correlation Coefficient: 0.9671

Refer to Figure 18 in Appendix I.

The regression analysis indicates that testing of 100 mm diameter x 200 mm cylinders would give somewhat higher results for concretes of <50 MPa strength and lower results for concretes of >50 MPa strength when compared with standard cylinder testing. However, this

test program gives results for concrete strengths of 35 MPa and greater and the regression line is therefore valid for concretes in this range. A set of further tests on lower strength concretes would be necessary to produce a valid correlation including strengths of 35 MPa and below.

6.9 Temperature Properties

The temperature development of the various cement factors was considered. The investigation was comparative in nature, with two 150 mm diameter x 300 mm cylindrical specimens being fabricated with cast-in-thermocouples for each cement factor. The temperature development of the specimens was monitored in controlled temperature conditions of 23 ± 2°C over the following 24 hours or until peak temperature was reached if this was later than 24 hours.

The test results for each cement factor are given in Figures 6, 7 and 8.

6.10 Flexural Strength vs Compressive Strength

The flexural strength/compressive strength relationship at 28 days for the different aggregate types are summarized below:

	Cement Factor			
Aggregate Type	450 kg/m^3	500 kg/m^3	450 kg/m^3 + S.F.	Mean
Gravel	13.2%	12.3%	11.5%	12.3%
Granite	14.6%	11.6%	14.1%	13.4%
Sandstone	13.9%	15.4%	13.8%	14.4%
Mean	13.9%	13.1%	13.1%	13.4%

Note: 1) Figures denote flexural strength as a percentage of compressive strength.
2) Compressive strengths from testing of 150 mm diameter x 300 mm cylinders have been used for this exercise.

The flexural strengths obtained are relatively consistent and close to the values which would be estimated using the formula (5-2) for high strength concrete as given in reference (3).

6.11 Splitting Tensile Strength vs Compressive Strength

The splitting tensile strength/compressive strength relationship at 28 days for the different aggregates are summarized below:

Aggregate Type	Cement Factor 450 kg/m^3	500 kg/m^3	450 kg/m^3 + S.F.	Mean
Gravel	8.4%	8.0%	7.7%	8.0%
Granite	9.0%	7.8%	7.6%	8.1%
Sandstone	8.5%	8.2%	6.4%	7.7%
Mean	8.6%	8%	7.2%	7.9%

Note: 1) Figures denote splitting tensile strength as a percentage of compressive strength.
2) Compressive strength figures from testing of 150 mm diameter x 300 mm cylinders were used in this exercise.

Splitting tensile strengths obtained in the tests are generally similar to those which would be estimated using the ACI formula (5-3) as given in reference (3).

7.0 CONCLUSIONS

1. Results indicate that it would be possible to make concrete meeting requirements for 70 MPa at 91 days using any of the three aggregates. Compressive strength performance of concrete mixes using the three different aggregates is similar.

The addition of 7% silica fume increases compressive strength by approximately 14% at 91 days.

2. The main area of concern would be freeze-thaw durability where only the sandstone aggregate concrete performed well.

The gravel and granite concretes had relatively poor freeze-thaw durability when tested in accordance with ASTM C-666, procedure A. However, further freeze-thaw testing is necessary to confirm the results of this test series.

3. Flexural strength and splitting tensile strength results for each of the three aggregate concretes were comparable to the values which would be estimated using the ACI formulae for high strength concrete.

4. The sandstone aggregate emerges as having slightly superior overall performance. In the plastic concrete the batches displayed a lower variability and the hardened concrete

characteristics were comparable to, or superior to those of concretes made with the gravel and granite aggregates.

5. This program indicates that the use of 100 mm diameter x 200 mm cylinders for testing of compressive strength produces results which correlate well with those given by standard cylinders.

6. Modulus of Elasticity values for all concretes tested were in the range of 33-39 GPa with the sandstone aggregate concrete values being the highest followed by gravel then granite.

References:

(1) A.M. Neville, "Properties of Concrete", 3rd Edition. Longman Scientific & Technical Publishers, 1987.

(2) Mindess S., Young J.F., "Concrete", Prentice-Hall International

(3) A.C.I. Committee 363, "State-of-the-Art Report on High Strength Concrete", ACI Journal, 1984.

APPENDIX A

Statement of Work

STATEMENT OF WORK

REQUIREMENT

1. The contractor will make a series of concrete mixtures to produce high strength concrete. The mixture proportions to be used are attached.

2. The coarse and fine aggregates will be from Newfoundland. Three potential sources of coarse aggregates 'likely' to be used in Offshore Construction will be selected by the contractor in consultation with the Mines Dept., Prov. of Newfoundland. Only one source of fine aggregate will be used.

3. Cement will be from a Newfoundland source.

4. Silica fume to be used will be from a source in Quebec.

5. Superplasticizers and air-entraining admixtures will be of Canadian origin, if possible.

6. Properties of fresh concrete will be determined.

7. The mechanical properties to be determined will include compressive strength (3, 7, 28, 91, 365 days), flexural strength (14 and 28 days), splitting tensile strength (14 and 28 days), and modulus of elasticity (28 and 91 days). Three specimens will be tested at each age. For compressive strength the effect of specimen size will be investigated by making both 100 x 200 mm and 150 x 300 mm cylinders at each of the above ages. All testing will be on 150 x 300 mm cylinders. For flexural strength, 75 x 100 x 400 mm prisms will be used.

8. Three sets of freezing and thawing testing will be performed using ASTM C 666 Procedure A.

9. Shrinkage measurements will be performed on test specimens made from all mixtures.

GENERAL

1. All moulds will be of steel or heavy-duty plastic types. Paper moulds shall not be used.

2. A counter-current type of concrete mixer will be employed. A tilting type of mixer shall not be used.

3. All aggregates shall be pre-soaked for 24 hours.

4. Densities of fresh and hardened concrete will be determined.

5. Within batch variation of test results will be determined.

6. Progress reports to be supplied every two months.

7. A complete and detailed list of mixing and testing equipment must be provided in the proposal. The Contractor must confirm that the equipment proposed has the full capacity to complete the requirement.

8. Temperature rise of fresh concrete will be measured using thermocouples.

9. Chemical analyses of cement and silica fume will be provided together with physical properties, grading and petrographic analyses of the C.A. and F.A. aggregates.

10. Final reports (six copies) written in good English with professionally drafted graphs and charts shall be other final deliverables. Final report shall follow the format of CANMET reports (a sample copy will be supplied on request).

Testing Schedule for Hardened Concrete

Test	Age	Number of Specimens to be Tested	Number of Mixes Tested
Compressive strength (ASTM C 39) of 150 x 300 mm cylinders	3 d 7 d 28 d 91 d 365 d	3 3 3 3 3	9
Compressive strength (ASTM C 39) of 100 x 200 mm cylinders	3 d 7 d 28 d 91 d 365 d	3 3 3 3 3	9
Flexural strength (ASTM C 78) of 75 x 100 x 400 mm prisms	14 d 28 d	3 3	9
Splitting tensile strength (ASTM C 496) of 150 x 300 mm cylinders	14 d 28 d	3 3	9
Modulus of Elasticity (ASTM C 469) of 150 x 300 mm cylinders	28 d 91 d	3 3	9
Resistance of concrete to rapid freezing and thawing (ASTM C 666, Proc. A)		2	3
Length change of hardened concrete (shrinkage) in air storage (ASTM C 157)		2	9
Microstructural determination of air-void content in hardened concrete (ASTM C 457), 75 x 100 x 400 prisms		2	9

Mixture Proportions

W/C + S.F.:	0.27
Slump:	75 - 100 mm
Air:	4 ± 0.5 %

Cement Factors

(i)	Cement only:	450 kg/m^3
(ii)	Cement + 7% silica fume:	(Cement - 450 kg/m^3) (Silica fume - 32 kg/m^3)
(iii)	Cement only:	500 kg/m^3

APPENDIX B

Aggregate Procurement and Processing Contract

PART 1 - GENERAL

1.1 Purpose

.1 Works to be carried out in this contract are intended to provide processed aggregates for use in a concrete trial mix program to be done by others.

1.2 Description of Work

.1 Work to be performed shall include excavation (mining) and removal of natural materials from specified field locations (sources), processing of raw material to produce concrete aggregates, stockpiling of processed aggregate, and transportation of any superfluous raw materials to Owner's storage facility.

1.3 Codes and Standards

.1 The following codes and standards shall be considered as part of this specification to the extent noted:

National Standard of Canada: CAN3-A23.1-M77
Concrete Materials and Methods of Concrete Construction

CAN3-A23.2-M77
Methods of Test for Concrete

1.4 Contractor's Use of Sites

.1 Contractor shall have exclusive and complete use of source sites for execution of work.

1.5 Fees and Permits

.1 Contractor shall obtain and pay for all necessary permits, approvals, or permissions required to complete the work specified herein, which shall include but not be limited to the following:

(a) quarry permits
(b) environmental approvals
(c) permissions and approvals of any private landowners.

1.6 Examination of Site

.1 Contractor shall be deemed to have visited all sites before tendering to have familiarized himself with the location, scope of work, and any temporary measures that may be needed to complete the work as specified.

1.7 Safety and Blasting

.1 Contractor shall carry out the works with careful attention to safety at all times and shall follow all applicable provincial and federal safety regulations.

.2 All blasting works shall be carried out by an experienced Newfoundland licensed blaster.

.3 All provincial regulations shall be strictly met with regards to transportation and storage of explosives.

1.8 Unacceptable Work

.1 If any unacceptable work or defaults occur then Contractor shall carry out all works necessary to meet the requirement of this specification as directed by the Owner's representative.

.2 The cost of any additional inspection or testing arising as a result of default shall be borne by the Contractor and the costs of any re-inspection or re-testing incurred by the Owner as a result of unacceptable work or default shall be set off against monies due to the Contractor under this contract.

1.9 Payment

.1 Payment for all works covered by this contract will be at the lump sum price given on the Tender Form.

1.10 Schedule

.1 Work is to be completed by

PART 2 - PRODUCTS

2.1 Quantities

.1 It is required to produce in stockpile the following quantities of processed aggregates meeting the requirements of this specification:

(a)	fine aggregate	10 tonnes
(b)	coarse aggregate (each of 3 sources)	7 tonnes

.2 Quantities shall be determined by weighing of processed aggregate during transportation to stockpiles.

2.2 Aggregate Properties - General

.1 Aggregates shall meet the requirements of Section 5.0 of CAN3-A23.1, and the additional requirements of Sections 2.3 and 2.4 of this specification. Testing shall be done to the appropriate requirements of CAN3-A23.2.

2.3 Fine Aggregate

.1 <u>Gradation</u> Gradation of fine aggregate shall be within the following limits:

Sieve Designation (mm)	Percent Passing by Weight
5.0	100
2.5	85 - 95
1.25	55 - 75
0.63	30 - 50
0.315	10 - 25
0.160	2 - 10

.2 Cleanliness Fine aggregate shall be free of organic contamination and shall have an organic Plate Number no higher than No. 2.

The amount of material finer than 80 um shall be 2.0% maximum and, of this, not more than 0.5% shall be finer than 10 um.

2.4 Coarse Aggregate

.1 Gradation Gradation of coarse aggregates shall be within the following limits:

Sieve Designation (mm)	Percent Passing by Weight
20	100
14	95 - 100
10	40 - 60
5	0 - 5

.2 Particle Shape It is intended to produce a particle shape that is roughly cubicle. When tested by CAN3-A23.2-13A procedures (but using a ratio of 2 instead of the designated 3 in Section 2.1 of that standard), the aggregates shall have a maximum of:

flat particles	15%
elongated particles	10%
flat and elongated particles	20%

.3 Cleanliness Coarse aggregate shall be free of organic contamination. The amount of material finer than 80 um shall be a maximum of 0.5%.

.4 Degradation Coarse aggregate when tested to CAN3-A23.1.16A for Grading C shall have a degradation loss less than 25%.

PART 3 - EXECUTION

3.1 Location of Sources

.1 Location of sources are shown on the drawings and described in Appendix A.

.2 Actual points at which excavation shall take place will be marked in the field by the Owner's representative.

3.2 Access to Sources

.1 Method of achieving access to sources for excavation and transportation equipment shall be the responsibility of the Contractor.

.2 Access shall be carried out with due regard to the environment and strictly in accordance with all provincial or federal regulations.

3.3 Excavation and Transportation

.1 Method of excavation and transportation of materials shall be the responsibility of the Contractor.

.2 Contractor will be responsible for removal of all vegetation and overburden, for excavating, mining and transporting material in a safe and efficient manner, and for leaving each location in a neat condition.

.3 At the two rock sources, weathered surface rock shall be removed prior to mining the source rock.

.4 Contractor shall ensure that sufficient raw materials are excavated to meet the quantity requirements for processed aggregate.

.5 Contractor shall use mining methods suitable for producing aggregates meeting this specification.

.6 On completion of mining works, all waste materials shall be backfilled into the excavation or otherwise disposed of in an environmentally acceptable manner, and the sites left in a neat condition to the satisfaction of the Owner's representative.

3.4 Processing

.1 Contractor shall use processing equipment suitable for producing aggregates meeting this specification.

.2 Processing shall include crushing, screening, and washing as appropriate.

.3 Crushing equipment shall be selected to produce the required coarse aggregate particle shape and shall not produce particles with incipient fractures such that the requirement of Section 2.4.4 cannot be met.

3.5 Stockpiling

.1 The Contractor shall produce four separate stockpiles using procedures that prevent segregation and contamination.

.2 Material will be removed from stockpiles by others for use in concrete mix trials.

.3 Any spare processed material and left-over raw material shall be transported to the Owner's storage facility at a location in St. John's.

3.6 Quality Assurance

.1 Designated testing agency for this contract shall be Nolan, Davis & Associates (1986) Limited.

.2 Contrctor shall co-operate with the testing agency and provide sampling access to aggregates during production, as required.

.3 Final acceptance of the Contractor's compliance to the specification will be based on the results of tests performed by the testing agency.

APPENDIX A

DESCRIPTION OF AGGREGATE SOURCES

A.1 Fine Aggregate Source

This is located on the southern bank of the Pipers Hole River estuary opposite the community of Swift Current. Newfoundland Department of Mines & Energy (NDME) have carried out considerable investigations of this source already, including extensive test pitting, petrographic analysis, gradation, soundness, absorption, and alkali aggregate reactivity (test results pending). An extension of the same deposit up-stream has been used by Atlantic Concrete as a source for concrete blending sand for many years.

NDME are confident that there are adequate volumes of material available at this site for the envisaged offshore developments. It appears that the whole deposit is generally similar in character and will be of acceptable quality for fine aggregate.

The selected source will be towards the centre of the deposit, in higher ground and sufficiently far from the river side so as not to be an environmental problem.

A.2 Coarse Aggregate Source 1 - Granite

Steep granite cliffs occur about 1 to 2 km inland from the proposed Swift Current fine aggregate source. Analyses of hand samples obtained from surface outcrops by NDME show a medium-grained granite with low petrographic number (Ref. Appendix B of CAN3-A23.2). Geological indications are that this source would probably produce a high quality aggregate and, since it occurs as a massive deposit, it should be able to be quarried to produce a uniform quality material.

A.3 Coarse Aggregate Source 2 - Sandstone

The second coarse aggregate source identified is on the east side of Placentia Bay in an area close to possible dry-dock sites. Geological investigations and hand sampling of rock outcrops by NDME indicate a band of hard sandstone trending roughly northeast-southwest and outcropping on the coast at Grassy Point.

Preliminary evaluation by NDME indicates this may be suitable for development, but, because it is a sedimentary deposit, selective mining methods may be necessary.

A.4 Coarse Aggregate Source 3 - Gravel

Prospective platform contractors have indicated a desire to investigate the possible use of coarse material obtained as a bi-product of fine aggregate processing, as coarse aggregate on its own, or as a blend material with other coarse aggregate, to aid workability. Material would be obtained from the same source as for fine aggregate.

TENDER FORM

SECTION	ITEM NO.	DESCRIPTION	LUMP SUM PRICE
02001	02001-1	Production of Concrete Aggregates	_____
		TOTAL TENDER PRICE:	_____

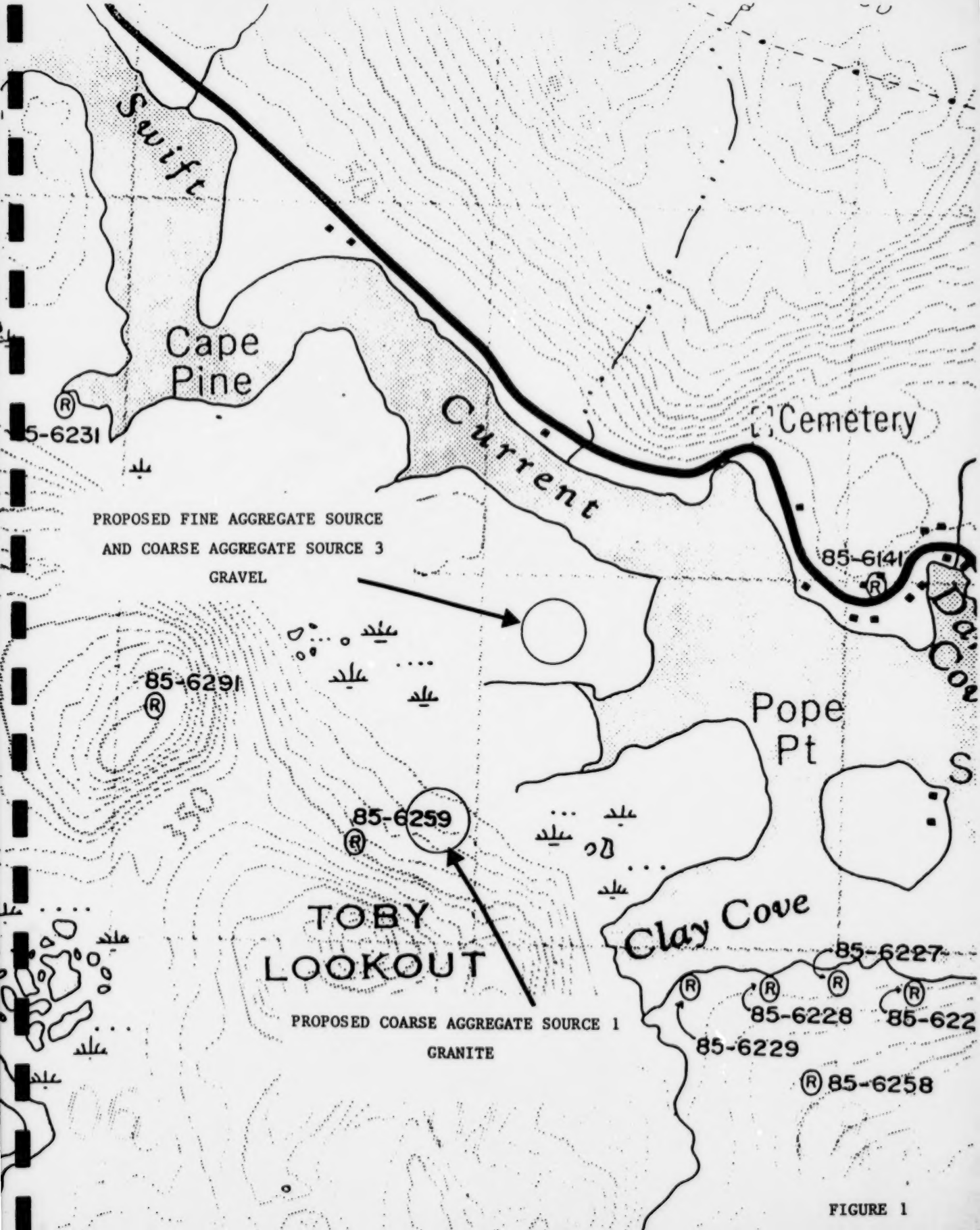
Swift
Cape
Pine
Current
Cemetery
85-6231
PROPOSED FINE AGGREGATE SOURCE
AND COARSE AGGREGATE SOURCE 3
GRAVEL
85-6141
85-6291
Pope
Pt
85-6259
TOBY
LOOKOUT
Clay Cove
85-6227
85-6228
85-6229
85-6258
PROPOSED COARSE AGGREGATE SOURCE 1
GRANITE

FIGURE 1

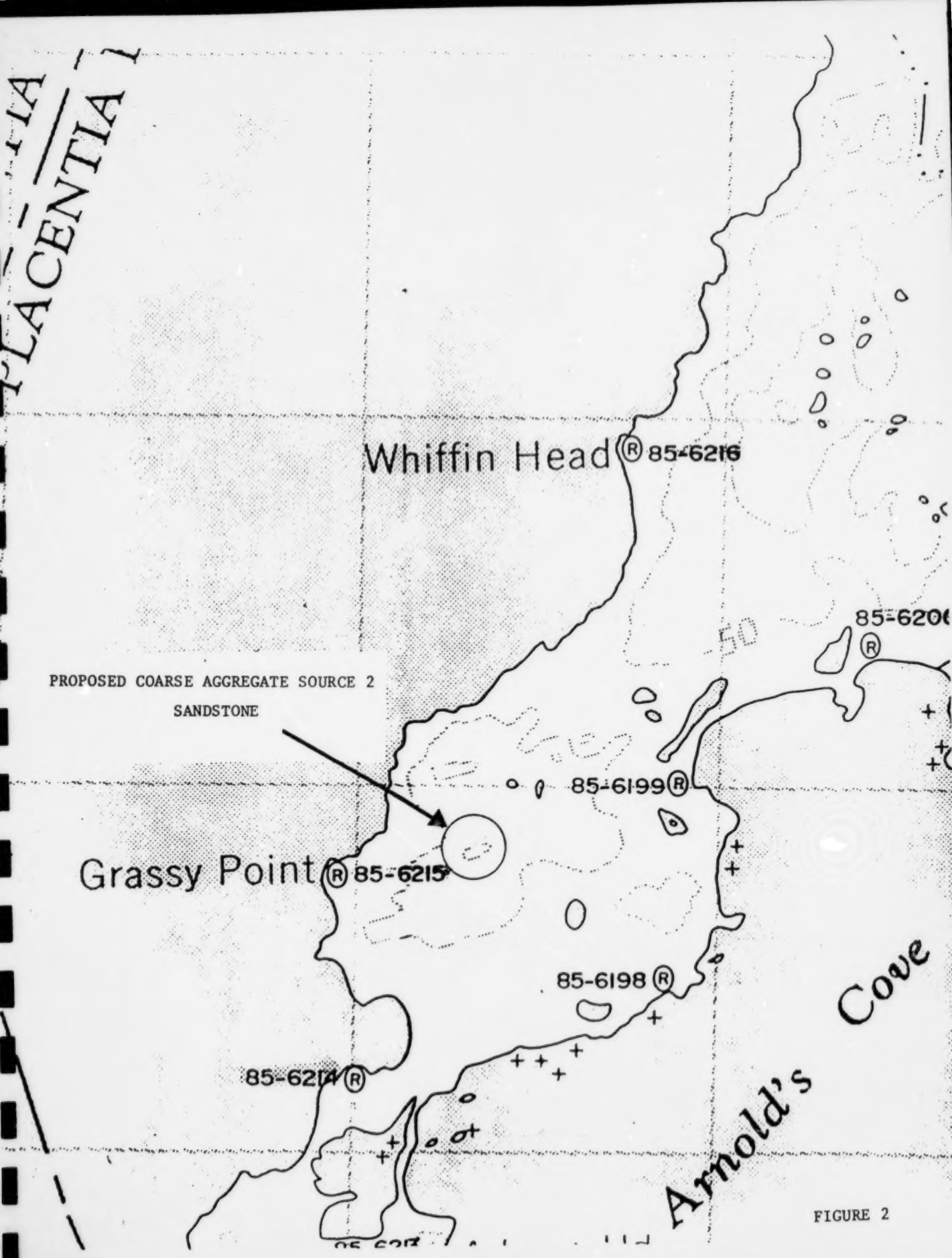
PLACENTIA
Whiffin Head
85-6216
85-6206
50
PROPOSED COARSE AGGREGATE SOURCE 2
SANDSTONE
85-6199
Grassy Point
85-6215
85-6198
85-6214
Arnold's Cove

FIGURE 2

APPENDIX C

Aggregate Properties

Project: C-01507-A

EVALUATION OF NEWFOUNDLAND AGGREGATES

TABLE I

Fine Aggregates

	Test	Result	CSA Standard
1.	Sieve Analysis	See Attached Forms	CAN3-A23.2-2A
2.	Relative Density and Absorption:		CAN3-A23.2-6A
	Bulk Specific Gravity	2.641	
	Absorption, %	1.012	
3.	Soundness of Aggregates by use of Magnesium Sulphate:		CAN3-A23.2-9A
	Corrected percentage loss by weight, %	1.27	
4.	Dry rodded density, kg/m^3	1761.56	CAN3-A23.2-10A
5.	Petrographic Analysis	See Table III c	CAN3-A23.2-15A

Project: C-01507-A

TABLE II
Coarse Aggregates

	Test	Result		CSA Standard
		Granite	Gravel	
1.	Sieve Analysis	See Attached Forms		CAN3-A23.2-2A
2.	Relative Density and Absorption:			CAN3-A23.2-12A
	Bulk Specific Gravity	2.722	2.721	
	Absorption,%	0.667	0.964	
3.	Soundness of Aggregates by use of magnesium sulphate:			CAN3-A23.2-9A
	Corrected percentage loss by weight, %	0.03	0.07	
4.	Dry rodded density, kg/m^3	1592	1699	CAN3-A23.2-10A
5.	Flat and elongated particles in coarse aggregate:			CAN3-A23.2-13A
	Size: 1/2 in.			
	Flat, %	6.7	6.4	
	Elongated, %	0	0	
	Neither flat nor elongated, %	93.3	93.6	
	Size 3/8 in.			
	Flat, %	6.5	4.3	
	Elongated, %	0	0	
	Neither flat nor elongated, %	94.5	95.7	
6.	Resistance to abrasion by use of the Los Angeles machine:			CAN3-A23.2-17A
	Loss, %	19.2	14.5	
7.	Petrographic Analysis	See Tables IIIa and IVb		

Project: C-01507-A

TABLE II
Coarse Aggregates
(continued)

	Test	Result Sandstone/Siltstone	CSA Standard
1.	Sieve Analysis	See Attached Form	CAN3-A23.2-2A
2.	Relative Density and Absorption:		CAN3-A23.2-12A
	Bulk Specific Gravity	2.719	
	Absorption, %	0.747	
3.	Soundness of Aggregates by use of magnesium sulphate:	Not Tested	CAN3-A23.2-9A
4.	Dry rodded density, kg/m^3	1565	CAN3-A23.2-10A
5.	Flat and elongated particles in coarse aggregate:		CAN3-A23.2-13A
	Size: 1/2 in.		
	Flat, %	20.0	
	Elongated, %	14.5	
	Flat and Elongated, %	1.8	
	Size: 3/4 in.		
	Flat, %	8.2	
	Elongated, %	6.4	
	Flat and Elongated, %	0.9	
6.	Resistance to abrasion by use of the Los Angeles machine:		CAN3-A23.2-17A
	Loss, %	10.0	
7.	Petrographic Analysis	See Table IIId	

Project: C-01507-A

TABLE IIIa

PETROGRAPHIC ANALYSIS

GRANITE

Petrographic Number:	125
Composition:	15-20% Quarts 70-80% Feldspars (50-60% of feldspars have minor sericite alteration) Less than 5% Biotite/Chlorite No visible porosity
Physical Characteristics:	Hard, slightly weathered surface weathering, contact between granite and diabase dyke.
Colour:	Pinkish-Grey
Grain Size:	Medium

Trow

Trow Geotechnical Ltd
1595 Clark Boulevard, Brampton
Ontario, Canada, L6T 4V1
Telephone: (416) 793-9800
Telex: 06-97802

Coarse Aggregate Petrographic Analysis

Site: Hibernia Project Project: G-01507-A/G Lab No.: 88-012

Date: June 7, 1988 Fraction: 19.0 mm - 9.50 mm Analyst: J.M. Robinson

NO.	ROCK TYPE	WEIGHT	PER CENT	GRANULAR & 16mm CRUSH CORRECTION	
1	CARBONATES (hard)				
20	CARBONATES (slightly weathered)				
2	CARBONATES (sandy, hard)				
21	CARBONATES (sandy, medium hard)				
23	CARBONATES CRYSTALLINE (hard)				
3	SANDSTONE - ARKOSE (hard)	63.8	6.8		
22	SANDSTONE - ARKOSE (medium hard)				
4	GNEISS - SCHIST (hard)	126.7	12.6		
5	QUARTZITE (coarse and fine grained)	26.7	2.6		
6	GREYWACKE - ARGILLITE (hard)				
7	VOLCANIC (hard and slightly weathered)	405.1	40.2		
8	GRANITE - DIORITE - GABBRO	132.0	13.1		
9	TRAP	187.5	18.6		
10	Quartz	21.8	2.2		
71	Iron Formation (Hard)	26.9	2.7		
	TOTAL GOOD AGGREGATE	995.0	98.8		
24	CARBONATES CRYSTALLINE (slightly weathered)			x2	
40	CARBONATES (soft; slightly shaley)			x2	
41	CARBONATES (sandy, soft and soft pitted)			x2	
42	CARBONATES (deeply weathered)				
25	GNEISS (soft) SCHIST (medium hard)			x2	
26	CHERT - CHERTY CARBONATES	3.1	0.3	x2	0.6
27	GRANITE - DIORITE - GABBRO (brittle)			x2	
28	VOLCANIC (soft)	1.1	0.1	x2	0.2
52	ENCRUSTATION			x2	
29	GREYWACKE - ARGILLITE (medium hard)			x2	
30	SANDSTONE - ARKOSE (brittle)			x2	
	TOTAL FAIR AGGREGATE	4.2	0.4		
43	CARBONATES (shaley or clayey)				
44	CARBONATES (ochreous)				
45	CHERT - CHERTY CARBONATES (leached)			x5	
46	SANDSTONE - ARKOSE (friable)			x3	
48	VOLCANIC (very soft, porous)			x3	
49	CARBONATES CRYSTALLINE (soft)			x3	
50	GNEISS (friable)			x3	
51	GRANITE - DIORITE - GABBRO (friable)			x3	
53	CEMENTATIONS			x3	
54	CEMENTATIONS (total)			x3	
55	SCHIST (soft)	9.1	0.9	x3	2.7
56	SILTSTONE (friable)			x3	
	TOTAL POOR AGGREGATE	9.1	0.9		
60	OCHRE				
61	SHALE				
62	CLAY				
63	VOLCANIC OR SCHIST (decomposed)				
	TOTAL DELETERIOUS AGGREGATE				
	TOTALS	1008.3	100.1		3.5

% Good	98.8	x1 =	98.8
% Fair	0.4	x3 =	1.2
% Poor	0.9	x6 =	5.4
% Deleterious		x10 =	

HOT MIX, MULCH AND CONCRETE P.N. 105

NOTE: This analysis does not take into account the potential of alkali-aggregate reactions.

CORRECTED GRANULAR AND 16.0mm CRUSHED P.N.

102

TABLE III b
GRAVEL

TABLE III c

FINE AGGREGATE PETROGRAPHIC ANALYSIS

SOURCE NAME: Hibernia Project

Project No.: G-01507-A/G

LOCATION: Newfoundland

ANALYST: J.M. Robinson

SAMPLE NO.: 88-014 DATE: May 20, 1988

SIEVE SIZE	4.75 - 2.36		2.36 - 1.18		1.18 - 600		600 - 300		300 - 150		150 - 075	
	#	%	#	%	#	%	#	%	#	%	#	%
SILICATE ROCKS (AND ASSOCIATED MINERALS. QUARTZ, FELDSPAR, AMPHIBOLE), SANDSTONE, QUARTZITE	200	100	199	99.5	200	100	200	100	200	100	200	100
CARBONATE ROCKS AND ASSOCIATED MINERALS, CALCITE, DOLOMITE			1	0.5								
SHALE, ARGILLITE (soft), CLAY, OCHRE												
MICA (Biotite, Muscovite' Chlorite)												
CHERT (Leached and Unleached), FLINT, JASPER												
CONTAMINATION, ie. glass, slag, coal, etc.												
CEMENTED PARTICLES												
TOTAL	200	100	200	100	200	100	200	100	200	100	200	100
GRADATION, PERCENT RETAINED ON INDIVIDUAL SIEVE	9.8		18.3		35.8		25.3		7.0		1.9	
ESTIMATED PERCENT TOTALLY CRUSHED PARTICLES												

COMMENTS AND NOTES:

WEIGHTED AVERAGE PERCENT CHERT 0.

PH-CC-437 86-12

Project: C-01507-A

TABLE IIId

PETROGRAPHIC ANALYSIS

SANDSTONE/SILTSTONE

Petrographic Number:	125
Composition:	Sample composed of 80% matrix, 20% grains. Clay matrix very fine-chlorite sericite, mica. Quartz grains - 15% Feldspar - 5% No visible porosity
Physical Characteristics:	Hard, fresh - slightly weathered surface weathering, highly fractured and jointed, alternating beds of sandstone/siltstones.
Colour:	Greenish-Grey
Grain Size:	Fine

Trow

Trow Inc.. Consulting Engineers
1595 Clark Boulevard. Brampton
Ontario. Canada. L6T 4V1
Telephone: (416) 793-9800
Telex: 06-97802

Aggregates Grading Form

Description of Sample: Sand (Shipment 2)

Project Name: Evaluation of Newfoundland Aggregates Project No.: C-01507-A/RD

Date Received or Sampled: March, 1988 Sample No.: 1

Date Tested: March 22, 1988 Sampled By: Client

Tested By: F. Soroye

Tested in accordance with CSA A23.1

Sieve Size	Accum. Wt. Retained	Accum. % Retained	Total % Passing	Project Requirements	CSA A23.1 Requirements for fine Aggregate	
10mm			100		100	
5mm			100	100	95-100	
2.5mm			94	85-95	80-100	
1.25mm			78	55-75	50-90	
630um			44	30-50	25-65	
315um			14	10-25	10-35	
160um			4	2-10	2-10	

Fineness Modulus: 2.66 2.3 - 3.1

Organic Impurities:

Passing 80 μm Sieve (wet screened) %:

Moisture Content as received %:

REMARKS:

Trow

Trow Inc., Consulting Engineers
1595 Clark Boulevard, Brampton
Ontario, Canada, L6T 4V1
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Telex: 06-97802

Aggregates Grading Form

Description of Sample: Sand (Shipment 1)

Project Name: Evaluation of Newfoundland Aggregates Project No.: C-01507-A/RD

Date Received or Sampled: Unknown Sample No.: 1

Date Tested: February 5, 1988 Sampled By: Unknown

Tested By: A. Li

Tested in accordance with CSA A23.1

Sieve Size	Accum. Wt. Retained	Accum. % Retained	Total % Passing	Project Requirements	CSA A23.1 Requirements for fine Aggregate	
10mm			100		100	
5mm			100	100	95-100	
2.5mm			95	85-95	80-100	
1.25mm			82	55-75	50-90	
630um			49	30-50	25-65	
315um			17	10-25	10-35	
160um			5	2-10	2-10	

Fineness Modulus: 2.52 2.3-3.1

Organic Impurities:

Passing 80 µm Sieve (wet screened) %: 0.34 2.0 max. 3.0 max.

Moisture Content as received %:

REMARKS:

Trow

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Ontario, Canada, L6T 4V1
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Telex: 06-97802

Aggregates Grading Form

Description of Sample: Granite

Project Name: Evaluation of Newfoundland Aggregates

Project No.: C-01507-A/RD

Date Received or Sampled: Unknown

Sample No.: 1

Date Tested: January 27, 1988

Sampled By: Unknown

Tested By: A. Li

Tested in accordance with CSA A23.1

Sieve Size	Accum. Wt. Retained	Accum. % Retained	Total % Passing	Project Requirements for Coarse Aggregates	CSA A23.1 Requirements for fine Aggregate	
28mm			100	100		
20mm			100	100		
14mm			84	95-100		
10mm			40	40-60		
5mm			3	0-5		

Fineness Modulus:

Organic Impurities:

Passing 80 μm Sieve (wet screened) %:

Moisture Content as received %: 0.55%

REMARKS:

Trow

Trow Inc., Consulting Engineers
1595 Clark Boulevard, Brampton
Ontario, Canada, L6T 4V1
Telephone: (416) 793-9800
Telex: 06-97802

Aggregates Grading Form

Description of Sample: Gravel

Project Name: Evaluation of Newfoundland Aggregates Project No.: C-01507-A/RD

Date Received or Sampled: Unknown Sample No.: 1

Date Tested: January 27, 1988 Sampled By: Unknown

Tested By: A. Li

Tested in accordance with CSA A23.1

Sieve Size	Accum. Wt. Retained	Accum. % Retained	Total % Passing	Project Requirements for Coarse Aggregates	Requirements for fine Aggregate	
28mm			100	100		
20mm			100	100		
14mm			90	95-100		
10mm			54	40-60		
5mm			3	0-5		

Fineness Modulus:

Organic Impurities:

Passing 80 μm Sieve (wet screened) %:

Moisture Content as received %: 0.57%

REMARKS:

Trow

Trow Inc., Consulting Engineers
1595 Clark Boulevard, Brampton
Ontario, Canada. L6T 4V1
Telephone: (416) 793-9800
Telex: 06-97802

Aggregates Grading Form

Description of Sample: Sandstone/Siltstone

Project Name: Evaluation of Newfoundland Aggregates

Project No.: C-01507-A/RD

Date Received or Sampled: May, 1988

Sample No.: 1

Date Tested: May 26, 1988

Sampled By:

Tested By: F. Soroye

Tested in accordance with CSA A23.1

Sieve Size mm	Accum. Wt. Retained	Accum. % Retained	Total % Passing	Project Requirements for Coarse Aggregates	CSA A23.1 Requirements for fine Aggregate	
28			100	100		
20			100	100		
14			86	95 - 100		
10			49	40 - 60		
5			11	0 - 5		

Fineness Modulus:

Organic Impurities:

Passing 80 μm Sieve (wet screened) %:

Moisture Content as received %: 0.24

REMARKS:

Project: C-01507-A

APPENDIX D

Properties of Cementitious Materials

Project: C-01507-A

Material: Portland Cement Type 10
Supplier: North Star Cement Limited

DATE: January 14, 1988

TABLE IV

CEMENT TEST REPORT - Type 10

SAMPLE: Shipment September 21, 1987

CHEMICAL:		CSA CAN3-A5-M83 TEST REQUIREMENTS
Loss on Ignition, (%)	2.20	max. 3.5
Insoluble Residue, (%)	0.40	max. 1.0
Sulphur Trioxide, (%)	3.88	if C_3A >7.5%, max. 3.5 if C_3A <7.5%, max. 3.0
Tri-calcium Aluminate (%)	6.00	N/R
Silica Dioxide, (%)	21.30	N/R
Ferric Oxide, (%)	3.24	N/R
Alumina, (%)	4.34	N/R
Calcium Oxide, (%)	59.81	N/R
Magnesium Oxide, (%)	3.69	max. 5.0
Total Alkalies, (%) (Na equiv.)	1.16	N/R
PHYSICAL:		
Fineness, (%)	96.4	min. 72
Soundness, (%)	0.16	max. 1.0
Sulphate Expansion, (%)	0.012	max. 0.020
Setting Time (minutes)	120	min. 45 max. 360
COMPRESSIVE STRENGTH:		
3 Day, (MPa)	21.8	min. 12.5
7 Day, (MPa)	26.4	min. 18.0
28 Day, (MPa)	34.8	min. 26.5

NOTE: Tested in accordance with CAN 3-A5-M83
Information supplied by manufacturer.
N/R - indicates No Requirement

Project: C-01507-A

Material: Silica Fume
Supplier: SKW Canada

TABLE V

BECANCOUR PLANT QUEBEC

TYPICAL CHEMICAL ANALYSIS OF SILICA FUME

	Si-FeSi 75%	CAN3-A23.5-M Test Requirements.
SiO_2	94.0	min. 85
Fe_2O_3	0.8	
Al_2O_3	0.3	
CaO	0.3	
MgO	0.4	
Na_2O	0.2	
K_2O	0.8	
C	1.0	
S	0.2	
L.O.I.	2.8	max. 6.0

TYPICAL PHYSICAL CHARACTERISTICS OF SILICA FUME

Specific surface area (m^2/kg)	18,000-20,000
Specific gravity	2.2
Bulk density (kg/m^3)	250-300
Fineness (ave. dia.) (μm)	0.1-0.2
Percent passing 45 μm (%)	95-100
Particle shape	spherical
Form	amorphous
Canadian Standard	CAN/CSA-A23.5-M86

Note: Information supplied by manufacturer.

APPENDIX E

Admixtures

CONCHEM

PRO AIR

PRODUCT DESCRIPTION

Pro-Air is an air entraining admixture for concrete.

USES

Pro-Air air entraining admixture is recommended for all concrete exposed to freeze/thaw cycles and all precast concrete.

FEATURES

Pro-Air introduces billions of microscopic air voids into the plastic concrete mix which will reduce bleeding and deterioration due to freeze/thaw cycles. Pro-Air helps improve water tightness, durability and reduces segregation during placement. Pro-Air was formulated to allow a limited ceiling on the amount of air that can be entrained into the concrete, thus providing protection against accidental overdose.

STANDARDS

CSA Can 3-A266.1-M78
ASTM-C-260
AASHTO - M-154
CRD- C.13

TECHNICAL DATA

Pro-Air is a water soluble hydrocarbon derivative.

APPLICATION

Pro-Air should be dispensed separately with the water at the time of batching. Do **not** mix directly with other admixtures. For applicable warranties refer to your local Conchem representative.

DOSAGE

Pro-Air should be added to the concrete at a rate of approximately 30-60 mL/100kgs. Cementitious material. Exact amount will vary with types of aggregate, cement, slump, temperature, etc.

SAFETY AND HANDLING

Caution: Caustic.
Avoid contact with eyes, in case of such contact, flush eyes thoroughly with water and seek medical attention. Do not take internally. Pro-Air should be stored at temperatures above freezing. Should freezing occur, Pro-Air must be agitated before using. Pro-Air is available in 205 L drums and bulk delivery.

PROTEX PDA

EXCLUSIVE LICENSEE

CONCHEM

CONCHEM S.P.N.

PRODUCT DESCRIPTION

Conchem S.P.N. is a water reducing super plasticizer.

USES

Conchem S.P.N. is a water reducing super plasticizer and can be used in all concrete applications.

FEATURES

Conchem S.P.N. is designed to provide high water reduction while maintaining the flowability of concrete providing:

— easier placement in heavily reinforced concrete
— improved bond to steel
— early removal of forms
— improved formed surfaces
— reduced placing costs
— lower water/cement ratio for high strength concrete

Conchem S.P.N. may be used as a component in the Protex Plus system.

Contact Conchem for formulations for hot weather concreting or other special situations.

STANDARDS

ASTM C 494 Type A
ASTM C 494 Type F

TECHNICAL DATA

Conchem S.P.N. meets requirements for both water reducing and high range water reducing admixture.

Test	Control	Conchem S.P.N.	% of Control	ASTM A	ASTM F
Compressive MPa					
1 day	12.40	19.77	159	—	140
3 day	26.35	30.52	143	110	125
7 day	29.49	35.82	121	110	115
28 day	37.68	44.30	118	110	110
6 mos	37.81	54.08	113	100	100
12 mos	50.15	59.46	119	100	100
Flexural MPa					
3 day	3.78	4.68	124	100	110
7 day	4.47	5.44	122	100	100
28 day	5.68	5.68	111	100	100

Settime

(Deviation from control)
Initial — 12 minutes later
Final — 4 minutes later

Length Change %

Control — .024
Conchem S.P.N. — .025

Durability — 97% of Control

* Test Mix contained 235 kg of Type 1 cement, designed for 2.5" ± .5" slump. Dosage rate was 12.8 fl. oz./cwt of cement.

PROPERTIES

Contains no chlorides. Colour — dark brown liquid. Spec gravity @ 20°C — 12 ± 2%
Density 1 kg/L
Viscosity @ 20°C — 70 cps
Solids — 42 ± 2%
pH (5% solution) 9.5 ± 1 Freezing point 23°F (-5°C)

APPLICATION

Order trial batch of concrete delivered to job site at specified initial slump (base slump). Check base slump and adjust with water if necessary to bring mix to within 25 mm of specified initial slump. Select starting dosage rate. Add Conchem S.P.N. onto the concrete mix by injecting into the drum of the truck or by backing concrete to rear of drum and pouring over the concrete Mix 4-5 minutes. Check slump. Place concrete — check for slump loss, bleeding, finishability, strength, etc.

DOSAGE

	Base Slump mm	Dosage for each 1 mm slump desired mL/100 kg cement
Conchem S.P.N.	25-50	6.4
	50-75	5.1
	75-100	3.8

SAFETY AND HANDLING

Avoid excessive delays in placing concrete after adding Conchem S.P.N. if long delay and loss of slump occurs, concrete may be redosed with Conchem S.P.N. Conchem S.P.N. is non-toxic, aqueous solution of unreactive synthetic organic chemicals. Normal care should be used in handling.

CONCHEM

PROLEX R

PRODUCT DESCRIPTION

Prolex R is a water reducing set retarding polymer admixture for concrete.

USES

Prolex R is recommended for use in all types of concrete where set retardation and superior performance is required. Prolex R may be used to effectively control the setting time across an entire slab area.

FEATURES

Prolex R set retarding admixture produces improved more consistant quality concrete providing set control, increased uniformity and water tightness. Some added advantages:
— increase-compressive and flexural strength
— does not promote bleeding
— increases density
Prolex R can extend the setting time for maximum retardation by varying the dosage rate as per Figure 1.

STANDARDS

Prolex R conforms to the following specifications:
CSA Can 3-A266.2-M78 Type SR
ASTM C-494

TECHNICAL DATA

Prolex R can be used with air entraining cements and air entraining admixtures. Prolex R is a component of Protex Plus system.
Note (basic composition)

APPLICATION

Prolex R should be dispensed separately with the water at the time of batching. Do **not** mix directly with other admixtures. For applicable warranties refer to your local Conchem representative.

DOSAGE

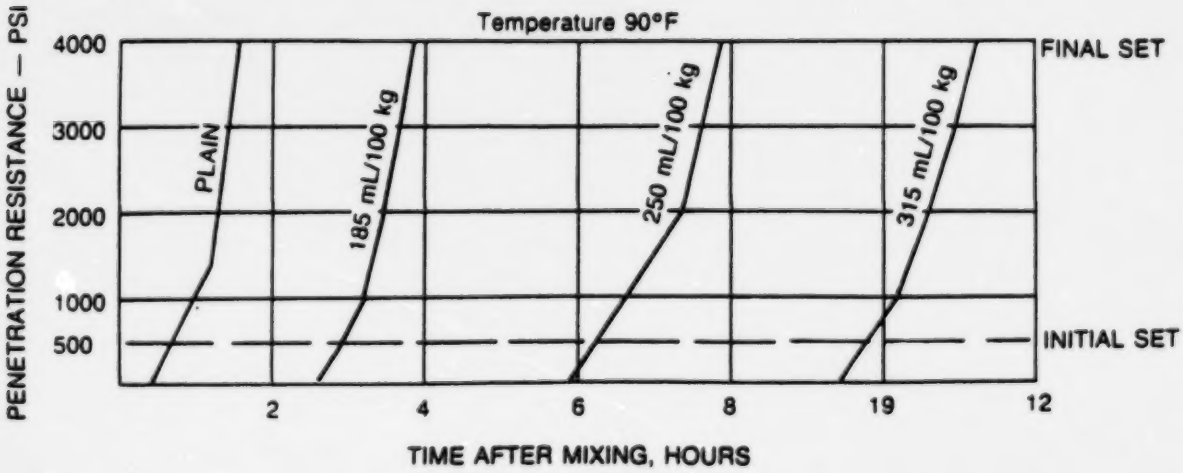
The normal dosage rate of Prolex R may vary from 150-375 mL/100kgs cementitious material. The dosage rate will vary with setting time requirements, components of the concrete, temperature and climate conditions. Prolex R should not be added in excessive amounts as prolonged setting may occur.

SAFETY AND HANDLING

Prolex R is slightly alkaline and non corrosive. Avoid contact with eyes, if contact occurs flush eyes thoroughly with water and seek medical attention. Do not take internally. Prolex R should be kept from freezing. Available in 20 L pails, 205 L drums and bulk delivery.

FIGURE 1

TABLE 1 — PROLEX R — Rate of Hardening at Various Dosages (ASTM C 403-63T)



Project: C-01507-A

APPENDIX F

Mix Proportions
and
Fresh Concrete Properties

Project: C-01507-A

EVALUATION OF NEWFOUNDLAND AGGREGATES

TABLE VI

Description of Mixes

Aggregate	Mix No.	Description
Granite	1	450 kg/m^3 Cement
	2	500 kg/m^3 Cement
	3	450 kg/m^3 Cement + 32 kg/m^3 Silica Fume
Gravel	4	450 kg/m^3 Cement
	5	500 kg/m^3 Cement
	6	450 kg/m^3 Cement + 32 kg/m^3 Silica Fume
Sandstone	7	450 kg/m^3 Cement
	8	500 kg/m^3 Cement
	9	450 kg/m^3 Cement + 32 kg/m^3 Silica Fume

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EVALUATION OF NEWFOUNDLAND AGGREGATES
TABLE VII
Concrete Mix Proportions

Mix/Batch	Cement	Silica Fume	Water	Aggregate Fine	Aggregate Coarse	Super.	W.R.A	A.E.A.
	Kg	Kg	Kg	Kg	(S.S.D.)	ml	ml	ml
Granite								
1/1	446	-	130	711	1131	11111	855	778
/2	449	-	130	711	1131	15556	855	778
/3	447	-	130	711	1131	17500	855	778
2/1	479	-	145	705	1116	6667	950	667
/2	492	-	145	705	1116	6667	950	667
/3	497	-	145	705	1116	6667	950	667
2R/1	496	-	144	667	1054	16546	943	827
/2	498	-	145	669	1058	16600	946	830
/3	498	-	145	669	1058	16600	946	830
3/1	457	32	140	680	1073	4778	916	778
/2	453	32	140	680	1073	4778	916	778
/3	450	32	140	680	1073	5556	916	778
Gravel								
4/1	449	-	130	711	1131	6667	855	778
/2	447	-	130	711	1131	6667	855	778
/3	448	-	130	711	1131	10000	855	778
5/1	492	-	145	705	1113	5556	950	889
/2	493	-	145	705	1113	5556	950	889
/3	491	-	145	705	1113	5556	950	889
6/1	462	33	140	662	1044	5250	916	875
/2	464	33	140	662	1044	5250	916	875
/3	464	33	140	662	1044	5250	916	875
Sandstone								
7/1	446	-	129	704	1150	9907	848	881
/2	451	-	131	712	1163	10024	858	891
/3	447	-	130	706	1153	9933	850	883
8/1	505	-	146	897	1070	9531	897	897
/2	506	-	147	899	1073	8994	899	899
/3	503	-	146	893	1066	8935	893	893
9/1	454	32	141	686	1081	8070	924	897
/2	456	32	141	689	1085	8213	927	900
/3	456	33	141	689	1058	8325	927	900

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EVALUATION OF NEWFOUNDLAND AGGREGATES

TABLE VIII

Fresh Concrete Properties

Mix/Batch	W/C	Slump (mm)	Yield (m3)	Unit Weight (Kg/m3)	Air Content (%)	Temp. (C)
Granite						
1/1	0.29	90	1.01	2399	5.5	28
/2	0.29	80	1.00	2418	4.9	27
/3	0.29	100	1.01	2405	5.0	24
2/1	0.29	250	1.04	2362	7.0	19
/2	0.29	90	1.02	2424	4.9	21
/3	0.29	0	1.01	2449	3.5	20
2R/1	0.30	110	1.00	2361	4.6	29
/2	0.29	90	1.00	2370	4.2	29
/3	0.29	130	1.00	2370	4.6	29
3/1	0.29	80	0.98	2429	4.0	22
/2	0.29	80	0.99	2458	4.3	23
/3	0.29	120	1.00	2436	4.0	22
Gravel						
4/1	0.29	90	1.00	2418	4.6	27
/2	0.30	130	1.01	2405	5.0	24
/3	0.29	80	1.00	2412	4.5	24
5/1	0.29	100	1.02	2424	5.5	20
/2	0.29	90	1.01	2430	4.0	21
/3	0.29	200	1.02	2420	5.7	20
6/1	0.29	130	0.97	2393	4.5	26
/2	0.29	140	0.97	2399	4.4	25
/3	0.29	135	0.97	2399	4.9	25
Sandstone						
7/1	0.29	200	1.00	2429	4.0	29
/2	0.29	120	1.00	2458	4.2	29
/3	0.29	130	1.00	2436	4.0	30
8/1	0.29	180	1.00	2398	4.5	22
/2	0.29	135	1.00	2404	4.3	22
/3	0.29	160	1.00	2388	4.1	23
9/1	0.29	150	1.00	2394	4.4	25
/2	0.29	110	1.00	2403	4.5	27
/3	0.29	200	1.00	2404	4.0	27

APPENDIX G

Specimen and Testing Schedule

TABLE IX

EVALUATION OF NEWFOUNDLAND AGGREGATE SOURCES

SPECIMEN AND TESTING SCHEDULE

Test	Specimen Dimensions	Test Age (days)	Number of Specimens Mix 1 B1	Mix 1 B2	Mix 1 B3	Mix 2 B1	Mix 2 B2	Mix 2 B3	Mix 3 B1	Mix 3 B2	Mix 3 B3	Mix 4 B1	Mix 4 B2	Mix 4 B3	Mix 5 B1	Mix 5 B2	Mix 5 B3	Mix 6 B1	Mix 6 B2	Mix 6 B3	Summary
1. Compressive Strength to ASTM C39 (C)	150 dia. x 300	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5 specimens per batch, all batches, all mixes
		7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
		28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
		91	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
		365	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
		Summary	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
2. Compressive Strength to ASTM C39 (C)	100 dia. x 200	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5 specimens per batch, all batches, all mixes
		7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
		28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
		91	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
		365	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
		Summary	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
3. Flexural Strength to ASTM C78 (F)	75 x 100 x 400	14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2 specimens per batch, all batches, all mixes
		28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
		Summary	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
4. Indirect Tensile Strength to ASTM C496 (T)	150 dia. x 300	14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2 specimens per batch, all batches, all mixes
		28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
		Summary	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
5. Modulus of Elasticity to ASTM C469 (M)	150 dia. x 300	28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2 specimens per batch, all batches, all mixes
		91	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
		Summary	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
6. Freeze/Thaw to ASTM 666A (F)	75 x 100 x 400								1	1								1	1		1 specimen from batches 1 and 2, mixes 3 and 6
7. Shrinkage to ASTM C157 (S)	100 x 100 x 300		1	1		1	1		1	1		1	1		1	1		1	1		1 specimen from batches 1 and 2, all mixes
8. Air Voids to ASTM C457 (A)	150 dia. x 300		1	1		1	1		1	1		1	1		1	1		1	1		1 specimen from batches 1 and 2, all mixes

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TABLE IX (continued)

EVALUATION OF NEWFOUNDLAND AGGREGATE SOURCES

SPECIMEN AND TESTING SCHEDULE

Test	Specimen Dimensions	Test Age (days)	Number of Specimens Mix 7 B1	Mix 7 B2	Mix 7 B3	Mix 8 B1	Mix 8 B2	Mix 8 B3	Mix 9 B1	Mix 9 B2	Mix 9 B3	Summary
1. Compressive Strength to ASTM C39 (C)	150 dia. x 300	3	1	1	1	1	1	1	1	1	1	5 specimens per batch, all batches, all mixes
		7	1	1	1	1	1	1	1	1	1	
		28	1	1	1	1	1	1	1	1	1	
		91	1	1	1	1	1	1	1	1	1	
		365	1	1	1	1	1	1	1	1	1	
		Summary	5	5	5	5	5	5	5	5	5	
2. Compressive Strength to ASTM C39 (C)	100 dia. x 200	3	1	1	1	1	1	1	1	1	1	5 specimens per batch, all batches, all mixes
		7	1	1	1	1	1	1	1	1	1	
		28	1	1	1	1	1	1	1	1	1	
		91	1	1	1	1	1	1	1	1	1	
		365	1	1	1	1	1	1	1	1	1	
		Summary	5	5	5	5	5	5	5	5	5	
3. Flexural Strength to ASTM C78 (F)	75 x 100 x 400	14	1	1	1	1	1	1	1	1	1	2 specimens per batch, all batches, all mixes
		28	1	1	1	1	1	1	1	1	1	
		Summary	2	2	2	2	2	2	2	2	2	
4. Indirect Tensile Strength to ASTM C496 (T)	150 dia. x 300	14	1	1	1	1	1	1	1	1	1	2 specimens per batch, all batches, all mixes
		28	1	1	1	1	1	1	1	1	1	
		Summary	2	2	2	2	2	2	2	2	2	
5. Modulus of Elasticity to ASTM C469 (M)	150 dia. x 300	28	1	1	1	1	1	1	1	1	1	2 specimens per batch, all batches, all mixes
		91	1	1	1	1	1	1	1	1	1	
		Summary	2	2	2	2	2	2	2	2	2	
6. Freeze/Thaw to ASTM 666A (F)	75 x 100 x 400								1	1		1 specimen from batches 1 and 2, mixes 3 and 6
7. Shrinkage to ASTM C157 (S)	100 x 100 x 300		1	1		1	1		1	1		1 specimen from batches 1 and 2, all mixes
8. Air Voids to ASTM C457 (A)	150 dia. x 300		1	1		1	1		1	1		1 specimen from batches 1 and 2, all mixes
9. Temperature rise	150 dia. x 300				1			1			1	1 specimen for each concrete batch 3 (optional) all mixes

APPENDIX H

Test Results

Project: C-01507-A

EVALUATION OF NEWFOUNDLAND AGGREGATES

TABLE X

Summary of Test Data

Test	Mix 1	Mix 2R	Mix 3	Mix 4	Mix 5	Mix 6	Mix 7	Mix 8	Mix 9
I) Compressive Strength (MPa): 150 x 300-mm Cylinders Age (Days)									
3	38.4	37.8	43.0	38.4	39.9	40.2	37.9	37.3	43.5
7	43.7	44.7	51.5	44.5	43.4	47.7	44.9	44.4	52.0
28	57.1	54.1	64.0	54.5	55.9	63.8	55.9	54.7	68.9
91	68.5	67.2	75.8	60.4	64.3	74.7	68.1	66.4	74.8
365	83.9	74.3	87.7	84.8	76.2	79.5	71.6	78.6	85.4
100 x 200-mm Cylinders Age (Days)									
3	36.4	40.3	40.0	41.0	40.4	42.3	36.8	42.6	44.9
7	43.2	38.3	52.5	41.6	46.3	51.8	47.3	47.4	56.9
28	53.5	58.2	60.5	55.0	55.4	56.2	60.3	59.7	69.4
91	64.1	68.0	75.2	58.0	62.5	70.5	69.3	67.8	79.4
365	75.8	70.2	90.8	76.0	71.8	76.0	69.9	68.2	79.1
II) Flexural Strength (MPa): 75 x 100 x 400-mm Prisms Age (Days)									
14	6.26	6.86	7.01	5.63	6.55	5.64	7.53	7.11	9.02
28	8.31	6.66	9.03	7.17	6.85	7.35	7.78	8.41	9.50
III) Split Tensile (KPa): 150 x 300-mm Cylinders Age (Days)									
14	4375	4060	4585	4410	4340	4305	4558	4247	4857
28	5215	4200	4865	4620	4480	4935	4747	4470	4403
IV) M.O.E. (MPa): 150 x 300-mm Cylinders Age (Days)									
28	32488	33379	34664	35366	36332	34290	37582	35483	36703
91	34020	33166	34071	36109	37160	35438	38827	39477	39763

Project: C-01507-A

EVALUATION OF NEWFOUNDLAND AGGREGATES

TABLE XI

Summary of Shrinkage Test Results

% Change in Length (Average of two specimens unless otherwise noted)

Age (Days):	Mix 1*	Mix 2R	Mix 3	Mix 4	Mix 5	MIx 6	Mix 7	Mix 8	Mix 9
Moist Curing									
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28	0.007	0.011	0.010	0.010	-0.050	0.004	-0.014	0.021	0.002
Air Curing:									
4	-0.003	0.001	0.005	-0.013	-0.061	-0.009	-0.027	-0.002	-0.012
7	-0.014	-0.009	0.001	-0.016	-0.069	-0.011	-0.029	-0.003	-0.011
14	-0.025	-0.016	-0.008	-0.023	-0.073	-0.021	-0.034	-0.012	-0.012
28	-0.026	-0.028	-0.010	-0.029	-0.083	-0.032	-0.045	-0.023	-0.021
56	-0.027	-0.040	-0.027	-0.033	-0.086	-0.037	-0.052	-0.034	-0.030
112	-0.041	-0.067	-0.035	-0.046	-0.090	-0.037	-0.059	-0.042	-0.034
224	-0.051	-0.064	-0.043	-0.060	-0.106	-0.046	-0.076	-0.051	-0.041
448	-0.046	-0.065	-0.047	-0.053	-0.137	-0.057	-0.073	-0.047	-0.046

% Change in Length During Dry Storage

Age (Days)									
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	-0.010	-0.010	-0.005	-0.023	-0.011	-0.013	-0.013	-0.023	-0.014
7	-0.021	-0.020	-0.009	-0.026	-0.019	-0.015	-0.015	-0.024	-0.013
14	-0.032	-0.027	-0.018	-0.033	-0.023	-0.025	-0.020	-0.034	-0.014
28	-0.033	-0.039	-0.020	-0.039	-0.033	-0.037	-0.031	-0.044	-0.023
56	-0.034	-0.051	-0.037	-0.043	-0.036	-0.041	-0.038	-0.054	-0.032
112	-0.048	-0.078	-0.045	-0.056	-0.040	-0.041	-0.045	-0.063	-0.036
224	-0.058	-0.075	-0.053	-0.070	-0.056	-0.050	-0.062	-0.073	-0.043
448	-0.053	-0.076	-0.057	-0.063	-0.087	-0.061	-0.059	-0.068	-0.048

Note: * One specimen only.

Project C-01507A/RD

EVALUATION OF NEWFOUNDLAND AGGREGATES

TABLE XII

Rapid Freeze-Thaw Test

Mix Ref.: 3 Date Cast: 04/05/1988

Cycle No.	SSD Wt. (gm)		Frequency No.		Wt. Change (%)		Relative Dynamic Modulus (%)	
	B1	B2	B1	B2	B1	B2	B1	B2
0	7777	7768	8095	8090	0.00	0.00	100.0%	100.0%
33	7775	7771	7950	7876	-0.03	0.04	96.4%	94.8%
34	7782	7778	7927	7824	0.06	0.13	95.9%	93.5%
53	7784	7785	7903	7742	0.09	0.22	95.3%	91.6%
80	7769	7779	7891	7138	-0.10	0.14	95.0%	77.8%
105	7790	7816	7888	7031	0.17	0.62	95.0%	75.5%
125	7790	7829	7858	6642	0.17	0.79	94.2%	67.4%
140	7793	7847	7839	3573	0.21	1.02	93.8%	19.5%
161	7791	*	7731	*	0.18		91.2%	
185	7799		7300		0.28		81.3%	
194	7805		7083		0.36		76.6%	
219	7792		6076		0.19		56.3%	
236	7808		5819		0.40		51.7%	
248	7814		5593		0.48		47.7%	
264	7817		5292		0.51		42.7%	

Note: * Test Terminated.

Project C-01507A/RD

EVALUATION OF NEWFOUNDLAND AGGREGATES

TABLE XIII

Rapid Freeze-Thaw Test

Mix Ref.: 6 Date Cast: 03/29/1988

Cycle No.	SSD Wt. (gm)		Frequency No.		Wt. Change (%)		Relative Dynamic Modulus (%)	
	B1	B2	B1	B2	B1	B2	B1	B2
0	7661	7712	8094	8168	0.00	0.00	100.0%	100.0%
15	7661	7712	8065	8115	0.00	0.00	99.3%	98.7%
32	7660	7711	8058	8088	-0.01	-0.01	99.1%	98.1%
65	7661	7709	8013	8071	0.00	-0.04	98.0%	97.6%
75	7711	7664	8002	8050	0.65	-0.62	97.7%	97.1%
85	7665	7714	7990	8036	0.05	0.03	97.4%	96.8%
113	7652	7716	7963	8033	-0.12	0.05	96.8%	96.7%
138	7667	7718	7929	8023	0.08	0.08	96.0%	96.5%
163	7670	7715	7892	8020	0.12	0.04	95.1%	96.4%
178	7670	7714	7877	8003	0.12	0.03	94.7%	96.0%
199	7664	7710	7862	7990	0.04	-0.03	94.3%	95.7%
223	7666	7710	7170	7130	0.07	-0.03	78.5%	76.2%
232	7668	7711	7068	6770	0.09	-0.01	76.3%	68.7%
257	7663	7707	5777	5820	0.03	-0.06	50.9%	50.8%
274	7660	7704	4904	4964	-0.01	-0.10	36.7%	36.9%
286	7664	7709	4839	4947	0.04	-0.04	35.7%	36.7%
299	7660	7704	4877	4916	-0.01	-0.10	36.3%	36.2%

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EVALUATION OF NEWFOUNDLAND AGGREGATES

TABLE XIV

Rapid Freeze-Thaw Test

Mix Ref.: 9 Date Cast: 06/21/1988

Cycle No.	SSD Wt. (gm)		Frequency No.		Wt. Change (%)		Relative Dynamic Modulus (%)	
	B1	B2	B1	B2	B1	B2	B1	B2
0	7700	7838	8460	8426	0.00	0.00	100.0%	100.0%
15	7697	7833	8382	8371	-0.04	1.73	98.2%	98.7%
35	7698	7831	8372	8358	-0.03	1.70	97.9%	98.4%
67	7699	7835	8355	8343	-0.01	1.75	97.5%	98.0%
83	7700	7834	8349	8319	0.00	1.74	97.4%	97.5%
113	7698	7832	8322	8330	-0.03	1.71	96.8%	97.7%
130	7696	7830	8317	8312	-0.05	1.69	96.6%	97.3%
157	7693	7829	8314	8302	-0.09	1.68	96.6%	97.1%
181	7694	7828	8305	8288	-0.08	1.66	96.4%	96.8%
198	7695	7829	8299	8274	-0.06	1.68	96.2%	96.4%
212	7694	7828	8286	8263	-0.08	1.66	95.9%	96.2%
227	7692	7828	8256	8252	-0.10	1.66	95.2%	95.9%
263	7694	7829	8242	8247	-0.08	1.68	94.9%	95.8%
299	7690	7831	8181	8167	-0.13	1.70	93.5%	93.9%
333	7695	7832	8141	8120	-0.06	1.71	92.6%	92.9%

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EVALUATION OF NEWFOUNDLAND AGGREGATES

TABLE XV

Air Void System Parameters

Mix No.	Specimen	Air Content Fresh %	Air Content Hardened %	Specific Surface mm^{-1}	Spacing Factor mm
1	B1	5.5	4.0	19.3	0.271
	B2	4.9	2.9	22.3	0.260
2R	B2	4.2	4.6	27.0	0.193
3	B1	4.0	3.9	23.0	0.224
	B2	4.3	3.6	29.2	0.189
4	B1	4.6	3.6	25.2	0.207
	B2	4.5	3.6	21.4	0.252
5	B1	5.5	3.2	22.3	0.263
	B2	4.0	2.8	21.8	0.298
6	B1	4.5	5.1	31.8	0.157
	B2	4.4	4.4	21.1	0.243
7	B1	4.0	2.8	26.1	0.234
	B2	4.2	2.9	25.7	0.232
8	B1	4.5	3.1	20.5	0.281
	B2	4.1	4.1	20.4	0.269
9	B1	4.4	4.4	19.1	0.256
	B2	4.5	4.3	19.0	0.255

APPENDIX I

Figures

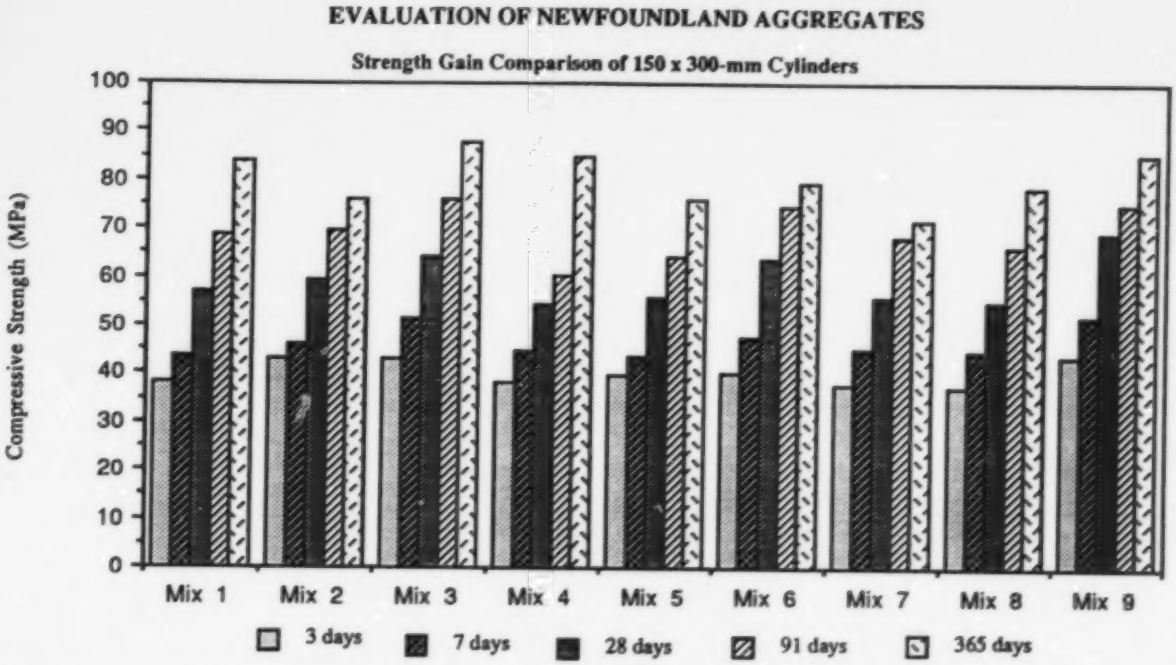

Figure 1

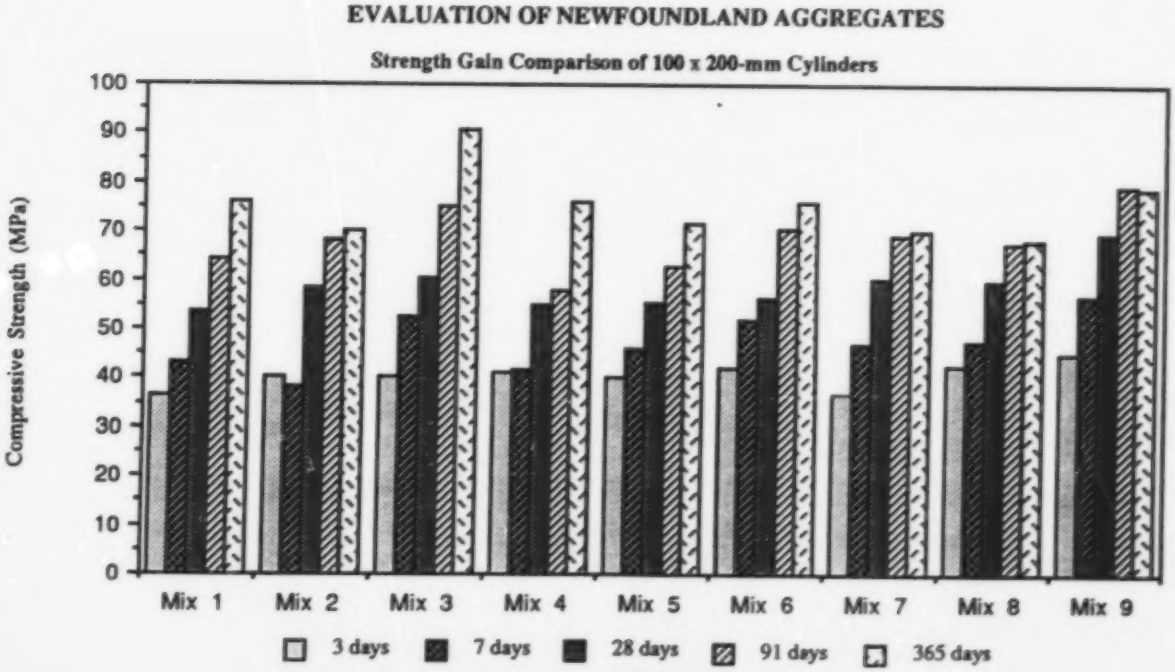

Figure 2

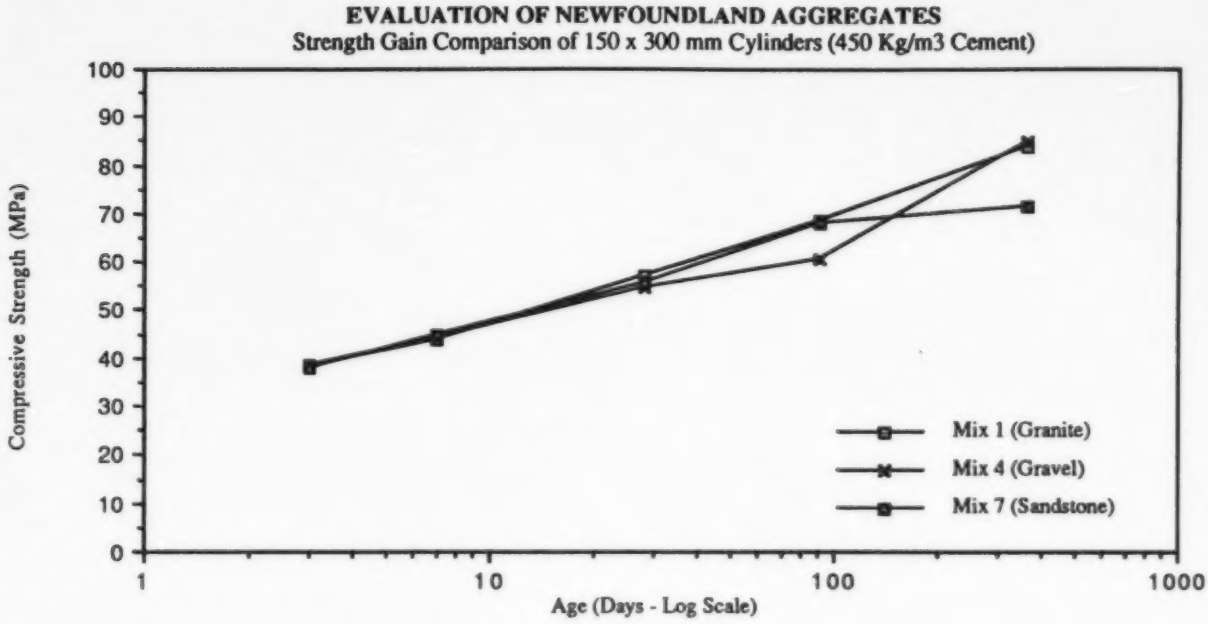

Figure 3

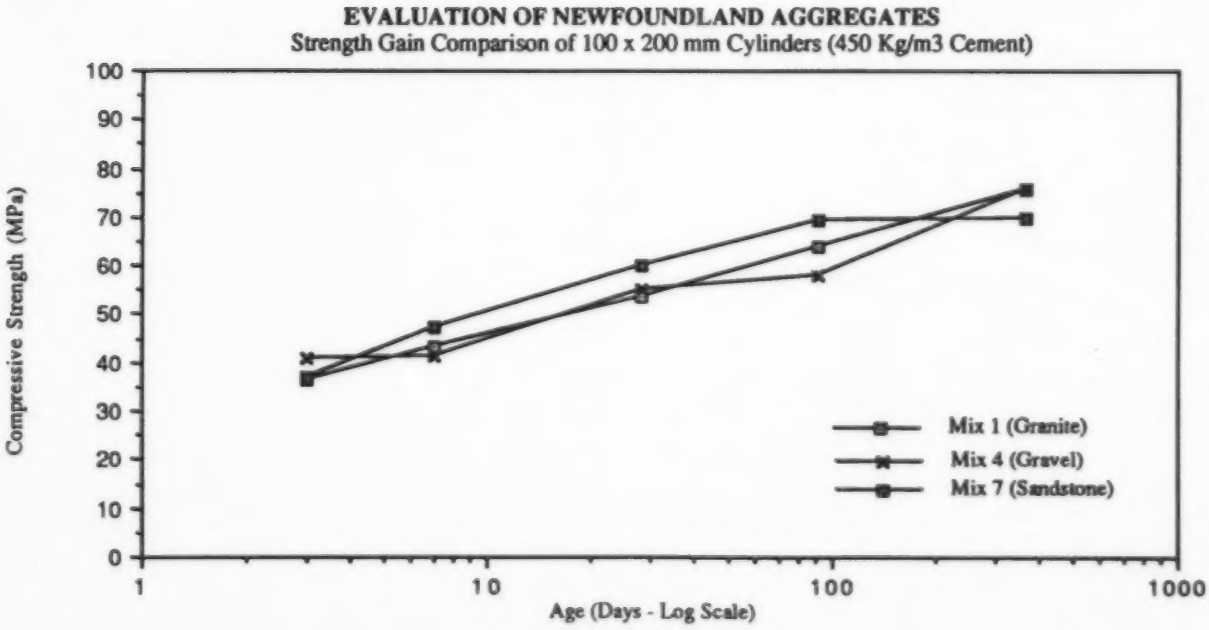

Figure 4

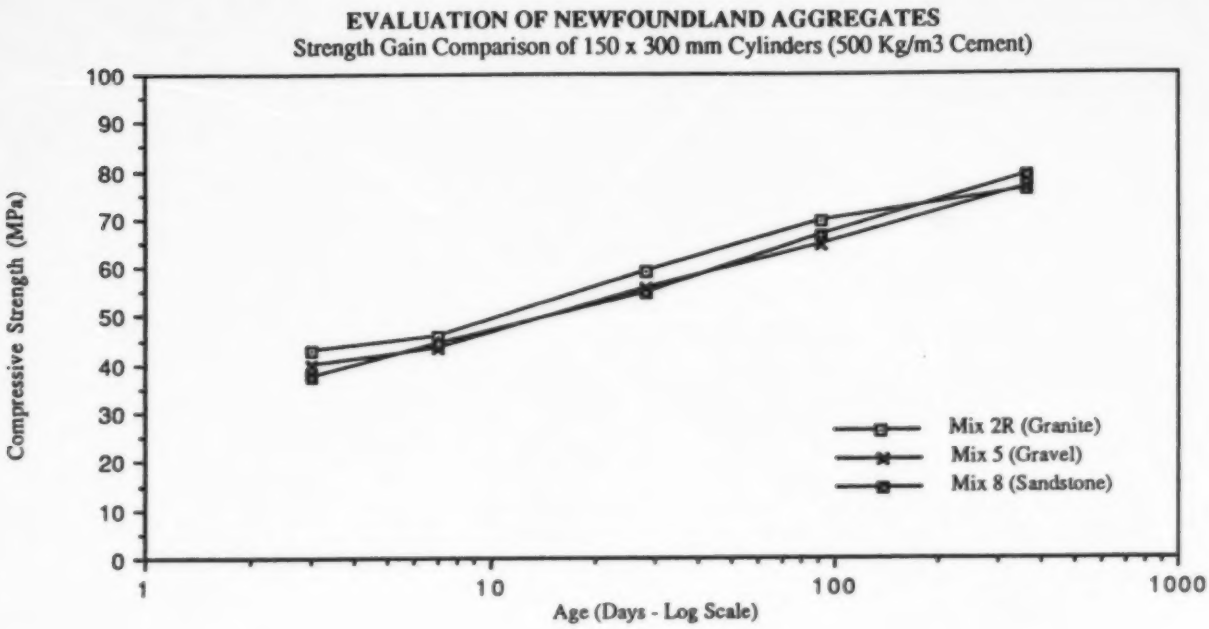

Figure 5

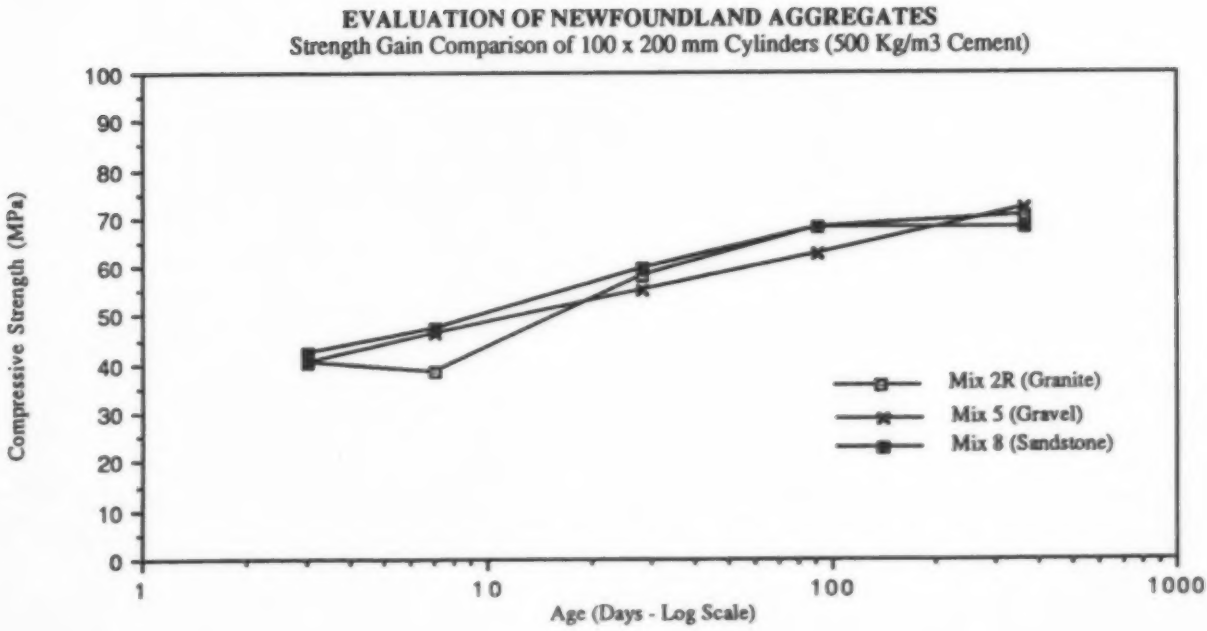

Figure 6

EVALUATION OF NEWFOUNDLAND AGGREGATES

Strength Gain Comparison of 150 x 300 mm Cylinders (450 Kg/m3 Cement + Silica Fume)

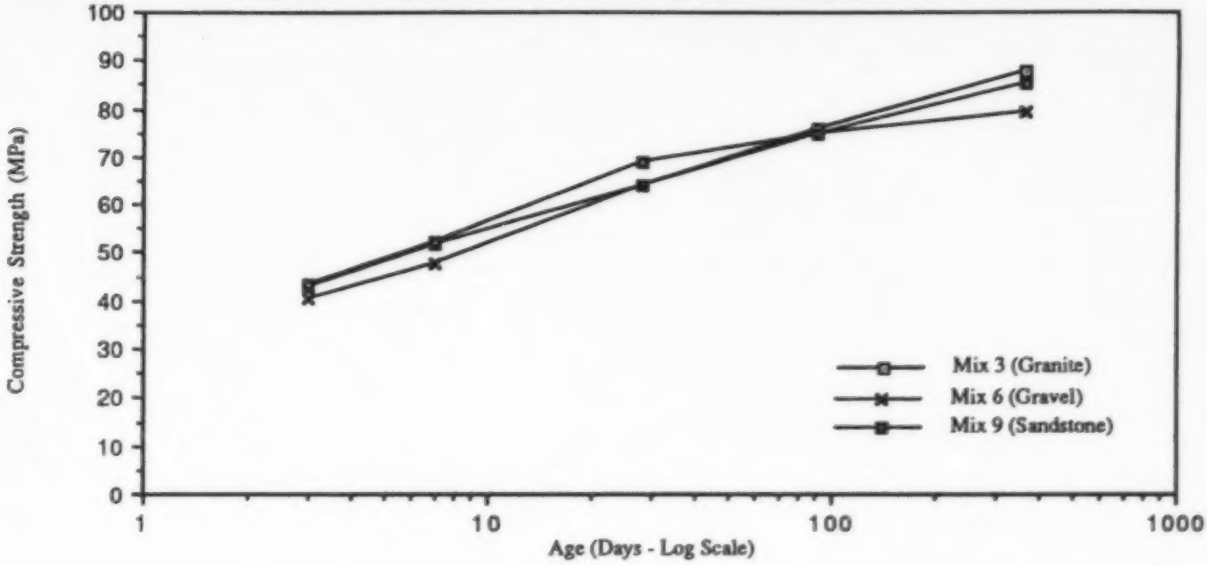

Figure 7

EVALUATION OF NEWFOUNDLAND AGGREGATES

Strength Gain Comparison of 100 x 200 mm Cylinders (450 Kg/m3 Cement + Silica Fume)

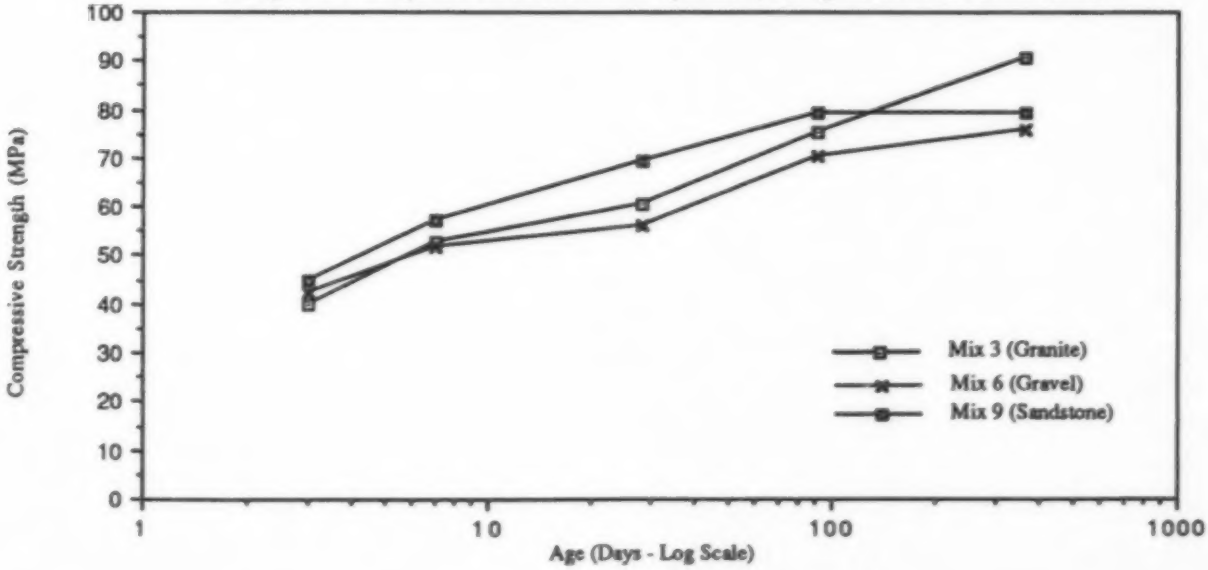

Figure 8

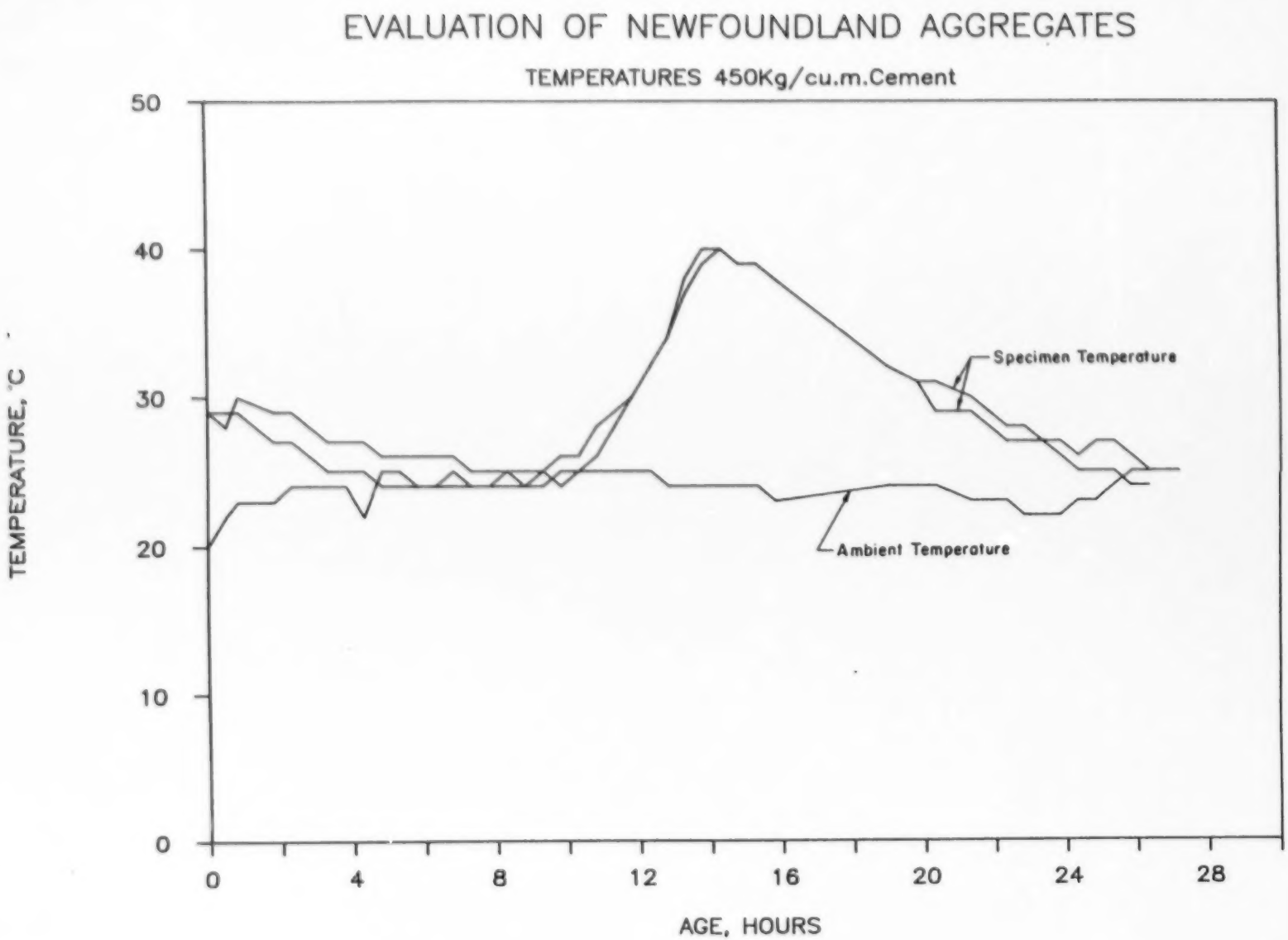
EVALUATION OF NEWFOUNDLAND AGGREGATES
TEMPERATURES 450Kg/cu.m.Cement
TEMPERATURE, °C
50
40
30
20
10
0
0
4
8
12
16
20
24
28
AGE, HOURS
Specimen Temperature
Ambient Temperature

Figure 9

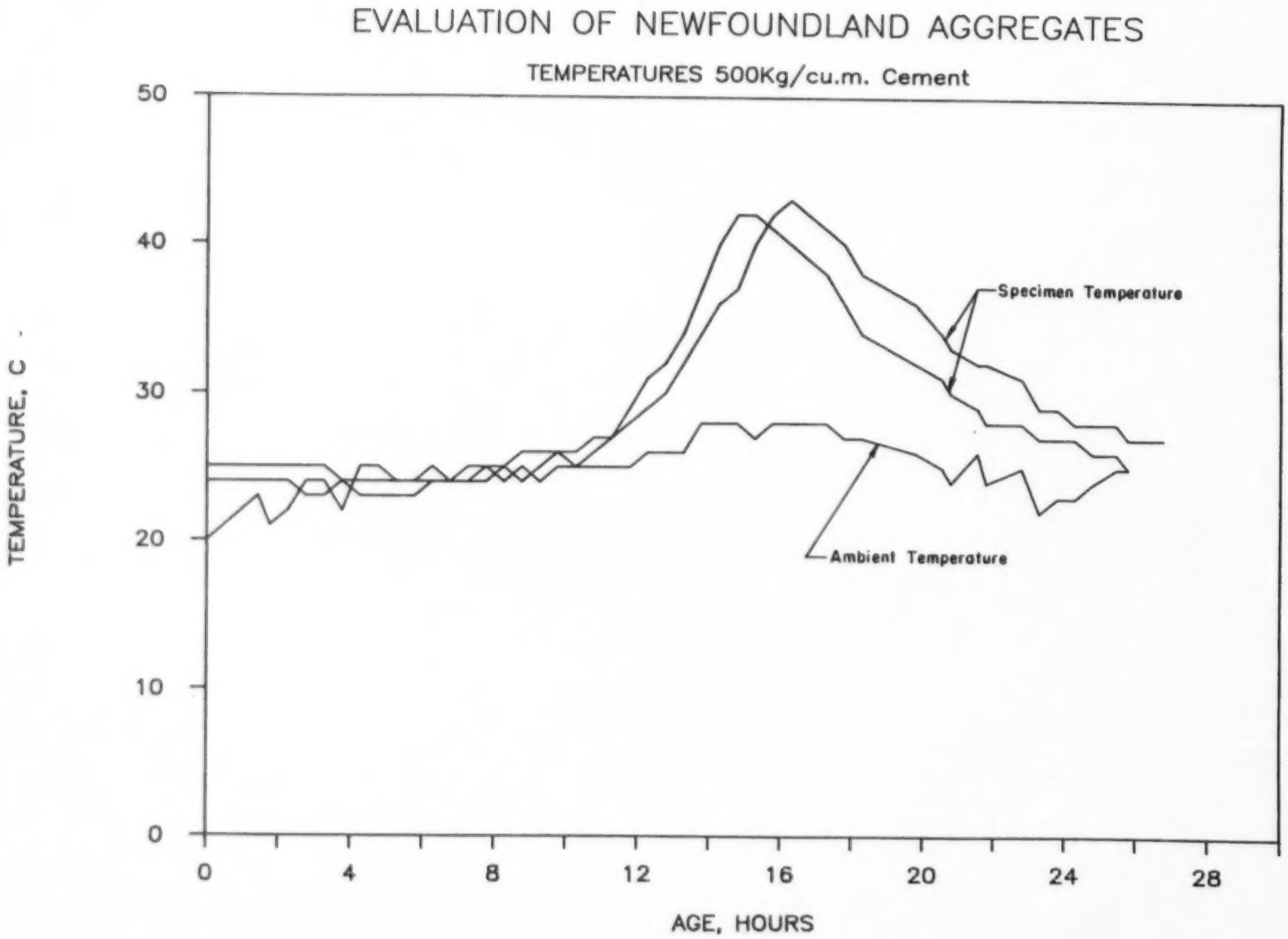
EVALUATION OF NEWFOUNDLAND AGGREGATES
TEMPERATURES 500Kg/cu.m. Cement
TEMPERATURE, C
50
40
30
20
10
0
0
4
8
12
16
20
24
28
AGE, HOURS
Specimen Temperature
Ambient Temperature

Figure 10

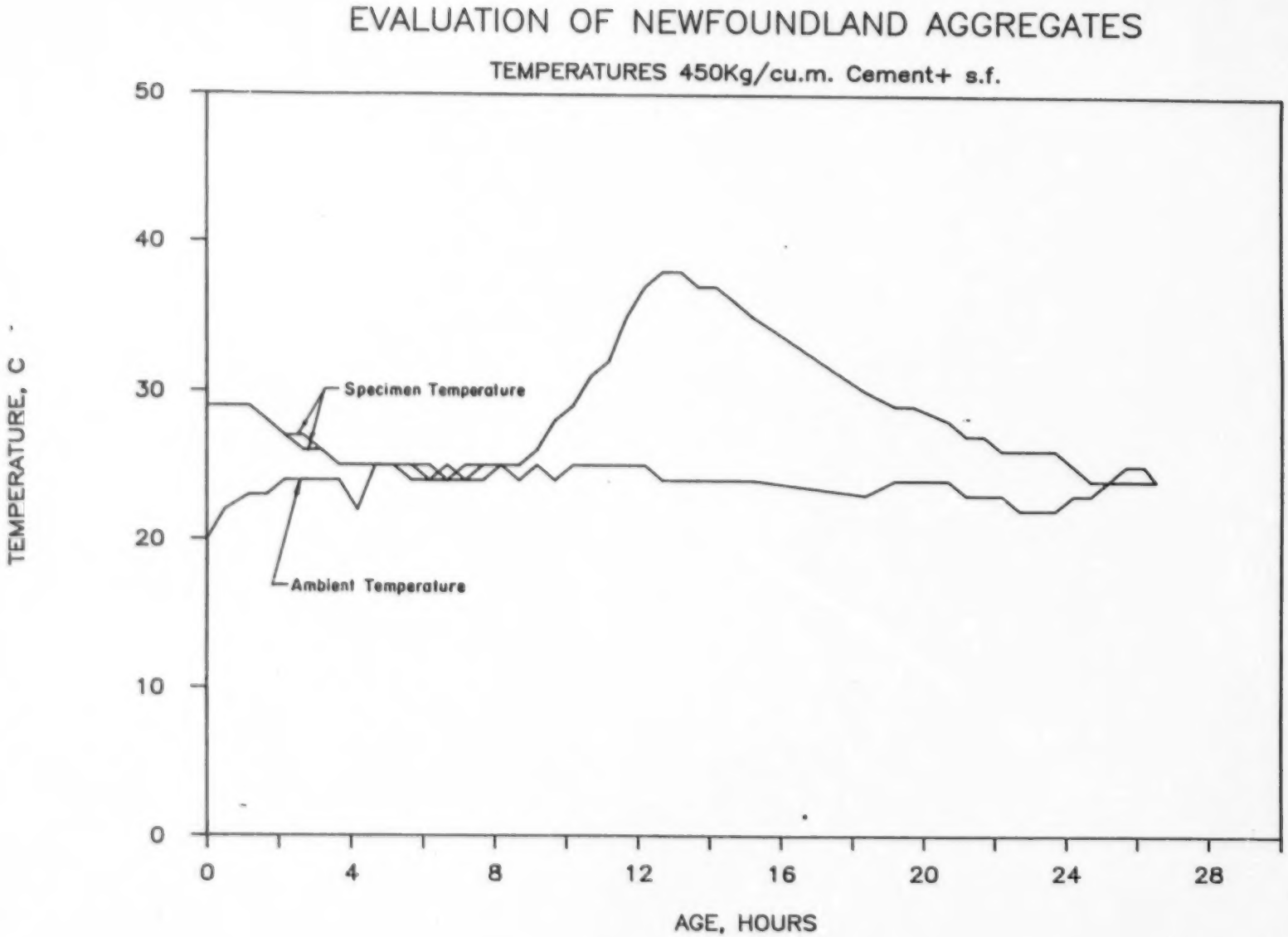
EVALUATION OF NEWFOUNDLAND AGGREGATES
TEMPERATURES 450Kg/cu.m. Cement+ s.f.
TEMPERATURE, C
50
40
30
20
10
0
Specimen Temperature
Ambient Temperature
0
4
8
12
16
20
24
28
AGE, HOURS

Figure 11

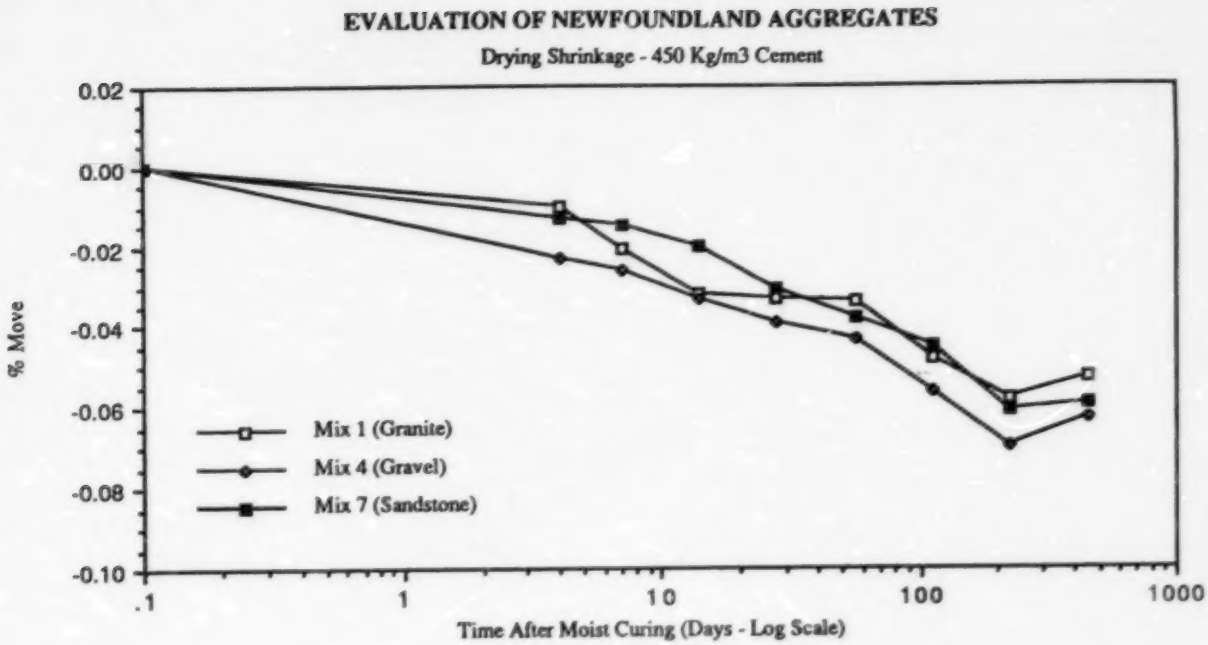

Figure 12

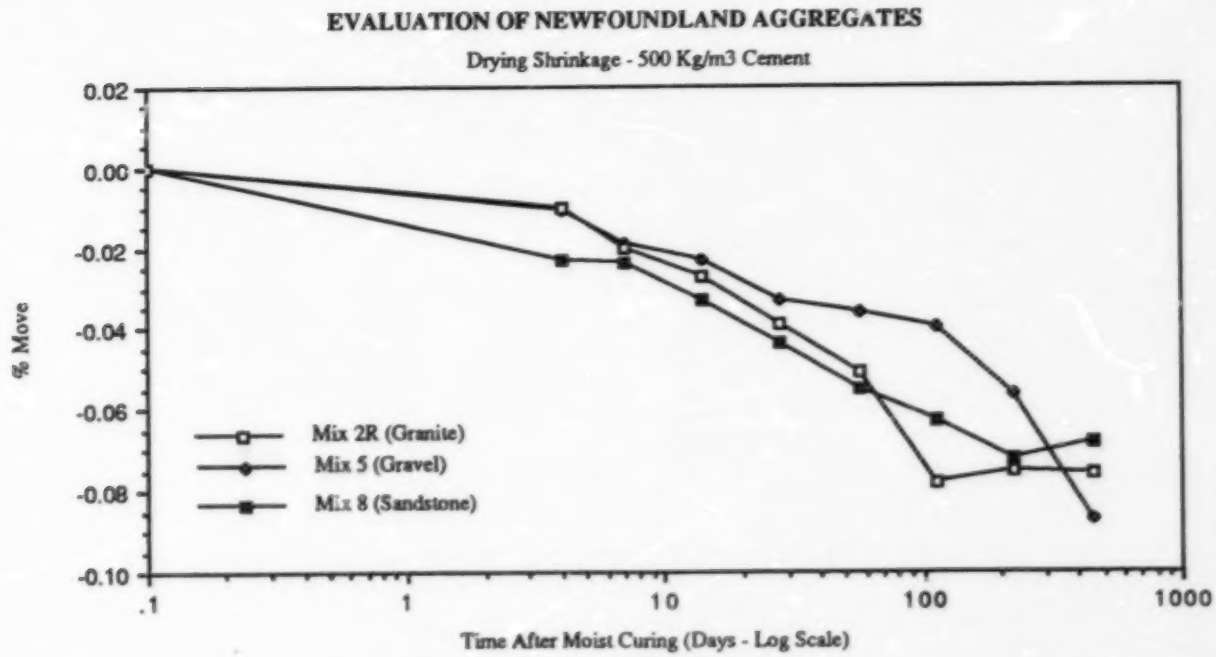

Figure 13

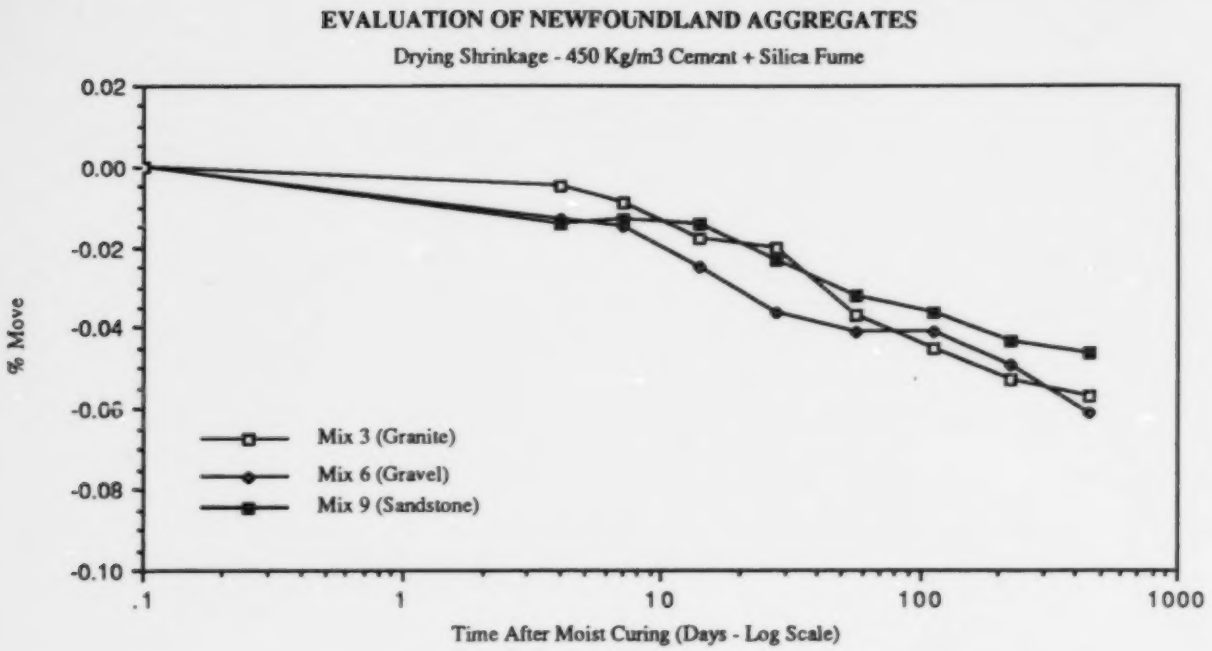

Figure 14

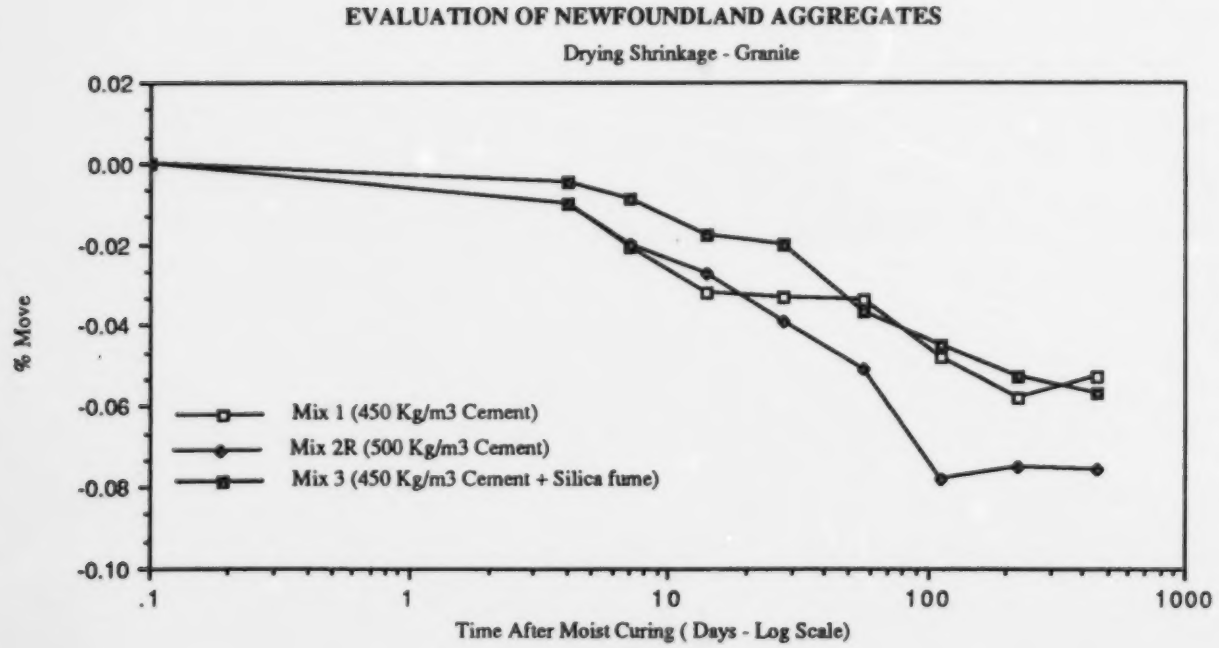

Figure 15

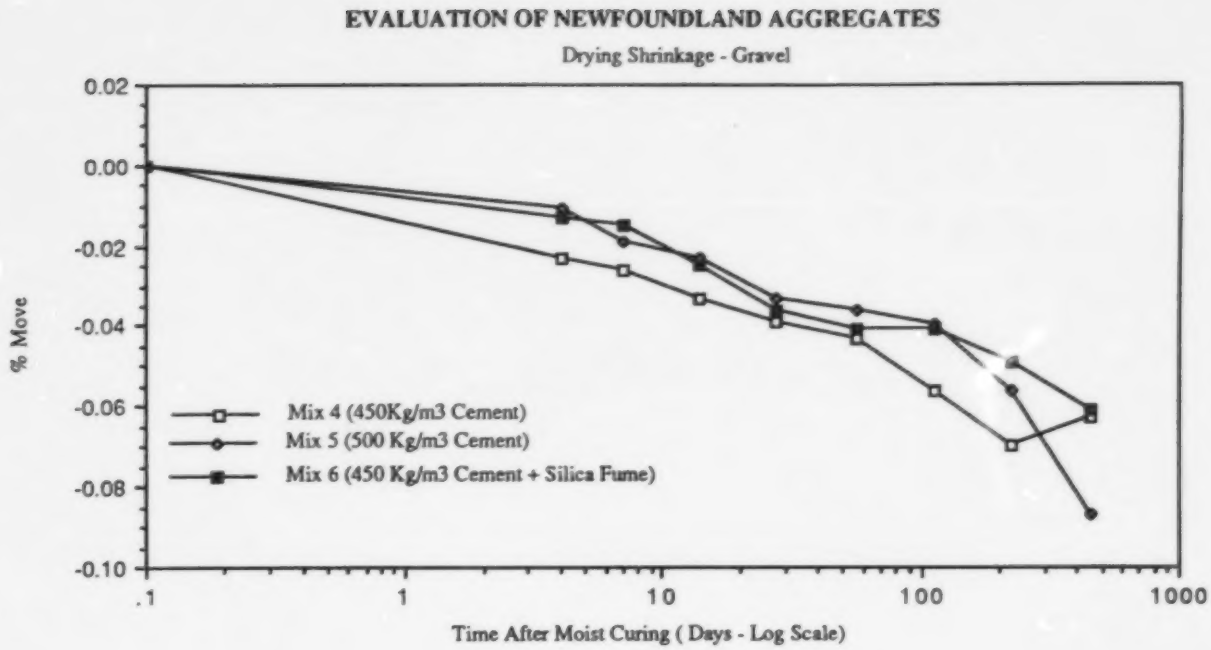

Figure 16

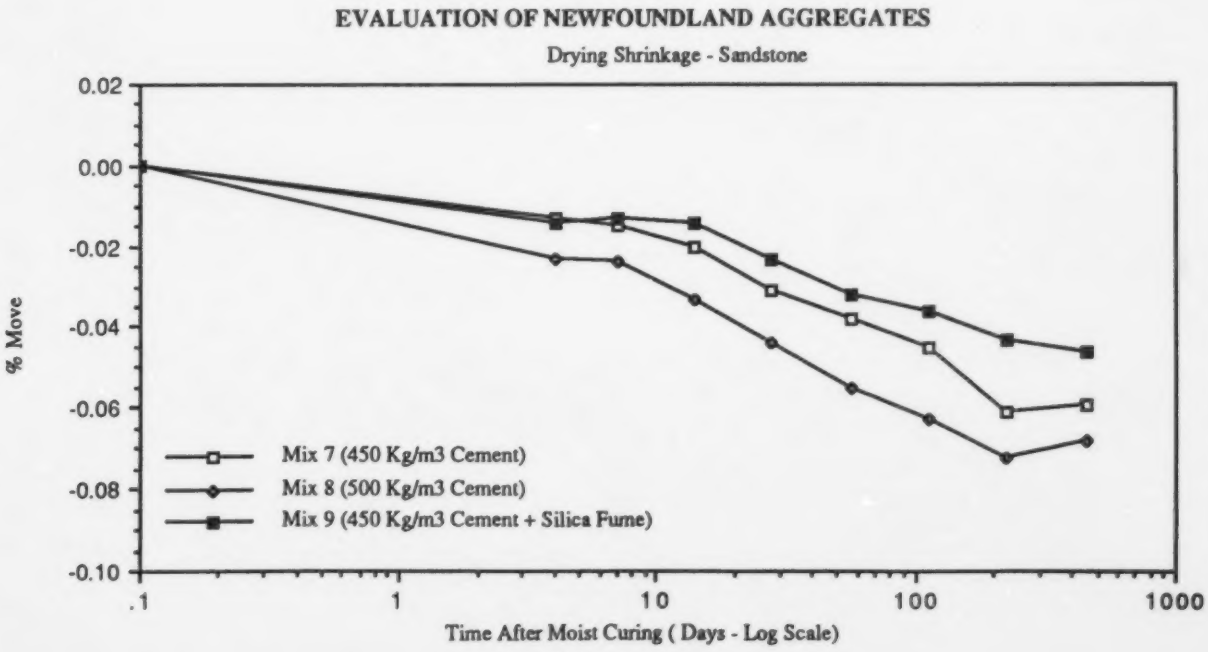

Figure 17

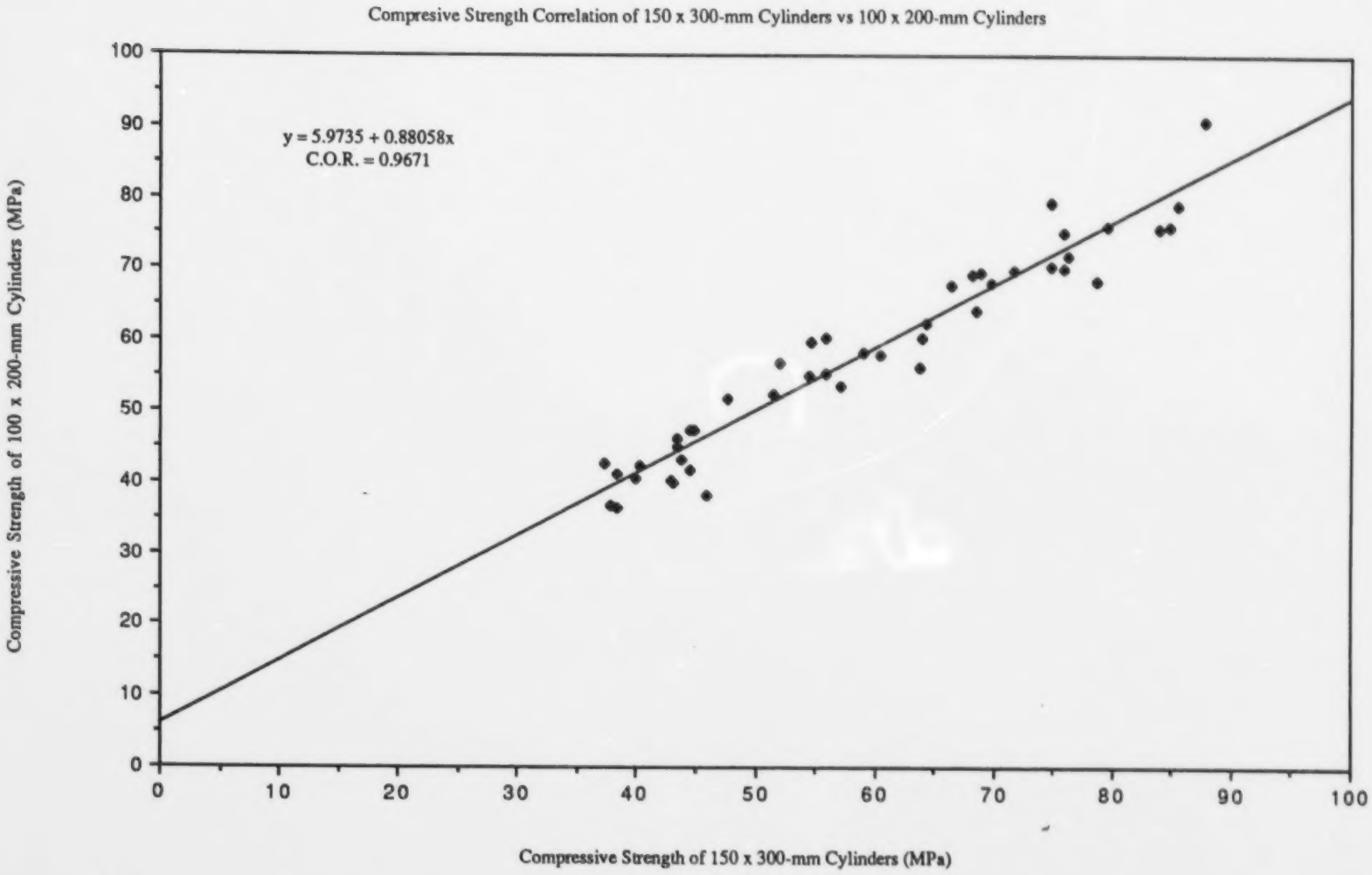
Compresive Strength Correlation of 150 x 300-mm Cylinders vs 100 x 200-mm Cylinders
y = 5.9735 + 0.88058x
C.O.R. = 0.9671
Compressive Strength of 100 x 200-mm Cylinders (MPa)
Compressive Strength of 150 x 300-mm Cylinders (MPa)
0
10
20
30
40
50
60
70
80
90
100

FIGURE 18